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The Engineer

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The Admiralty Engineering Laboratory (With a Two-Page Supplement).

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The James Forrest Lecture.

New Cotton Depot at Bombay.

Refractory Materials Congress.

The French Navy and Oil Fuel.

PUBLIC NOTICES

War Dept.

TENDERS are REQUIRED for the PURCHASE and REMOVAL of the undermentioned MACHINERY at—

R.E. STORES, NEW-ROAD, WOOLWICH.

ONE Crossley GAS ENGINE, 10 H.P., fitted with new piston and other parts, all in good condition.

CHARLTON PARK, CHARLTON.

ONE Gardiner PETROL-PARAFFIN ENGINE, 50 H.P., complete with MOTOR GENERATOR, voltage 220.

ONE Dallis and Mortice PETROL ENGINE, 20 H.P., complete with 15 K.W. GENERATOR, voltage 220 (new 2 years ago).

Permits to inspect, forms of Tender, conditions of sale, and all other necessary information may be had on application to the Commanding Royal Engineer, R.E. Office, New-road, Woolwich, S.E., on or before 15th May, 1923.

(Signed) R. L. WALLER,
Lt.-Col., R.E., Commanding R.E., Woolwich.
10th May, 1923. 2456

G. R.

Disposal and Liquidation Commission.

PATENTS FOR FIXATION OF NITROGEN.

The Disposal & Liquidation

Commission have been instructed by the Treasury to dispose of the Government's interests in certain patents covering new processes for the fixation of nitrogen, based on investigations carried out at the Research Laboratory established during the War under the auspices of the Nitrogen Products Committee. These inventions include more than twenty completed British patents, together with, in many cases, corresponding patents taken out in a number of British possessions and foreign countries for processes comprising the synthesis of ammonia, the preparation and purification of gases, the oxidation of ammonia, and the preparation of nitrates.

The whole rights of the Government in these inventions are now offered for sale, subject to the right of Messrs. Brunner, Mond and Co., Ltd., to non-exclusive licences.

Particulars may be obtained from the Consulting Engineers to the Commission—

MESSRS. J. F. CROWLEY & PARTNERS,
16, Victoria-street,
WESTMINSTER, S.W. 1.

by whom offers will be received for the whole or any of the inventions not later than May 25th.

The Commission reserves to itself the right not to accept the highest or any offer that may be received. 2451

University of Birmingham.

JAMES WATT RESEARCH FELLOWSHIP.

The Council invites APPLICATIONS for the JAMES WATT RESEARCH FELLOWSHIP in the Thermo-Dynamics of Internal Combustion Engines. Candidates should hold an Honours Degree in Engineering of a British University, and have had some experience in research. The Fellowship has at present an annual value of £220 and is renewable. Applications should be sent in not later than 31st of May, 1923.

Further particulars may be obtained from the Dean of the Faculty of Science, The University, Edgbaston, Birmingham.

GEO. H. MORLEY,
2414 Secretary.

Administrative County of

LONDON.

The London County Council invites TENDERS for a NEW CORNISH BOILER (with Fittings) for Culloden-street School, Poplar, E. 14; the boiler to be 6ft. diameter by 15ft. long.

Persons desiring to Tender may obtain on and after Monday, 14th May, 1923, the drawings, specification, form of Tender, &c., on application to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £2. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specifications, and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th May, 1923, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
2413 Clerk of the London County Council.

Administrative County of

LONDON.

The London County Council invites TENDERS for WATER SOFTENING and DE-OILING PLANT for the Northern Outfall Works, East Ham, E. 6 (alongside Beckton Gasworks); each plant to be capable of dealing with 1500 gallons of water an hour.

Persons desiring to Tender may obtain on and after Monday, 14th May, 1923, the drawing, specification, form of Tender, &c., on application to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £2. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawing, specification, and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th May, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
2444 Clerk of the London County Council.

Bombay, Baroda, and Central

INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Wednesday, 30th May, TENDERS for the SUPPLY of:

1. LAMINATED SPRINGS.
2. HELICAL or VOLUTE SPRINGS.
3. STEEL TYRES for LOCOMOTIVES.
4. CRANK and STRAIGHT AXLES for LOCOMOTIVES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W. 1,
8th May, 1923. 2436

PUBLIC NOTICES

County of London.

RECONSTRUCTION OF POOL BRIDGE, LEWISHAM.

The London County Council invites TENDERS for the RECONSTRUCTION of the County bridge known as Pool Bridge carrying Southend-lane over the Pool River, in the Metropolitan Borough of Lewisham.

Persons desiring to Tender may obtain the form of Tender, &c., on application to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th May, 1923, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
2408 Clerk of the London County Council.

County of London.

WIDENING OF YORK-ROAD BRIDGE, KING'S CROSS.

The London County Council invites TENDERS for the WIDENING of YORK-ROAD BRIDGE, KING'S CROSS, over the Regent's Canal, in the Metropolitan Boroughs of St. Pancras and Islington.

Persons desiring to Tender may obtain the form of Tender, &c., on application to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th May, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
2407 Clerk of the London County Council.

Liverpool Corporation Water-

WORKS.

TRUNK MAIN FROM PRESCOT TO LIVERPOOL.—CONTRACTS NOS. 4 AND 5.

RAILWAY CROSSINGS.

The Water Committee of the Liverpool Corporation are prepared to receive TENDERS from competent persons willing to enter into a contract for work in connection with the Crossing of the following Railways at Broadgreen, Liverpool, viz.:—

CONTRACT NO. 4.—Crossing of the Cheshire Lines Railway: ERECTION of BRICK PIERS and a 40in. STEEL TUBE.

CONTRACT NO. 5.—Crossing of the London, Midland and Scottish Railway: ERECTION of a STEEL PLATE GIRDER BRIDGE and a 40in. STEEL TUBE.

The plans may be inspected and copies of the specification and form of Tender obtained on and after Monday, 14th May, 1923, at the Water Engineer's Office, Alexandra Buildings, 55, Dale-street, Liverpool, upon payment of the sum of Three Guineas, which amount will be refunded upon receipt of a bona fide Tender and the return of the documents issued.

Tenders, endorsed "Tender for Railway Crossings," are to be sent through the post in a sealed envelope, addressed "Chairman of the Water Committee, Town Clerk's Office, Municipal Buildings, Liverpool," so as to be delivered not later than Twelve o'clock Noon on Tuesday, the 29th May, 1923.

The Water Committee do not bind themselves to accept the lowest or any other Tender.

WALTER MCCN,
Town Clerk.

Municipal Buildings, Liverpool,
10th May, 1923. 2410

PUBLIC NOTICES

City of Chichester.

EXTENSION OF WATER MAINS.

The Town Council of the City of Chichester invite TENDERS for the SUPPLY and LAYING of approximately TWELVE HUNDRED LINEAL YARDS of 3in. CAST IRON (or other approved material) WATER MAINS in the Bosham area. Tenders to include supply of all materials and labour.

Forms of Tender and quantities may be obtained and the specification inspected at the City Engineer's Office, 62, South-street, Chichester, upon the deposit of One Guinea. The Council do not bind themselves to accept the lowest or any Tender.

Tenders, in sealed envelopes and endorsed "Water Mains," must be delivered at my office not later than Noon on the 23rd day of May, 1923.

J. W. LOADER COOPER,
Town Clerk.

Town Clerk's Office,
East-street, Chichester. 2433

Department of Public Works.
Sydney, 31st January, 1923.

SYDNEY HARBOUR BRIDGE TENDERS—EXTENSION OF TIME.

Tenders are Invited by the

Government of New South Wales for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1600ft. in the clear, centre to centre of main piers, and a length of main bridge 2600ft. centre to centre of anchor piers. The total length of main bridge and approach spans included in Tender is 3810ft.; also an ALTERNATIVE TENDER for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of an ARCH BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1650ft. in the clear, centre to centre of bearings. The total length of main bridge and approach spans included in Tender is 3770ft. Either bridge is to provide for four lines of railway, six lines of vehicular traffic, and footway accommodation.

Copies of specification, including plans, technical information, general conditions, and Tender forms, may be obtained by bona fide tenderers on application to the Under-Secretary for Public Works, Sydney, or to the Agent-General for New South Wales, Australia House, The Strand, London; the Minister of Railways and Canals, Ottawa; the Australian Trade Commissioner in the United States, New York; or the Bureau of Foreign and Domestic Commerce, Washington, D.C., United States.

Tenders, the time for which has been extended, must reach the Under-Secretary for Public Works, Sydney, New South Wales, not later than 30th November, 1923.

R. T. BALL,
2033 Minister for Public Works and Railways.

The South Indian Railway Com-

PANY, Limited, are prepared to receive TENDERS for the SUPPLY of:—

1. PLATE GLASS.
2. LAMPS and FITTINGS, LAMP GLASSES, &c.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Plate Glass," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 25th May, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for a copy of each specification.

Copies of the drawings may be obtained at the offices of Messrs. Robert White and Partners, Consulting Engineers to the Company, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
7th May, 1923. 2439

PUBLIC NOTICES

The Metropolitan Asylums

Board invite TENDERS for the OPENING OUT, REPAIRING, and CLOSING UP of the ENGINES, BOILER, and AUXILIARY MACHINERY of the RIVER AMBULANCE STEAMER "WHITE CROSS," in accordance with specification prepared by Mr. Thomas Cooper, M.I.C.E., M.I.M.E., Engineer-in-Chief to the Board.

Specification, conditions of contract, and form of Tender may be obtained at the office of the Board, Victoria Embankment, London, E.C. 4.

Tenders, addressed as noted on the form, must be delivered at the office of the Board not later than 10 a.m. on Wednesday, 23rd May, 1923.

G. A. POWELL,
2445 Clerk to the Board.

Burma Railways.

ASSISTANT LOCOMOTIVE AND CARRIAGE SUPERINTENDENT WITH ELECTRICAL TRAINING.

The Directors are prepared to receive APPLICATIONS from qualified candidates for APPOINTMENT as ASSISTANT LOCOMOTIVE and CARRIAGE SUPERINTENDENT on the above railway.

Candidates should be single and between 23 and 28 years of age, and must have had a good general education. In addition to having served an apprenticeship as a pupil or privileged apprentice in the Locomotive Carriage and Wagon Department of a British Railway Company, they must have been trained in the theory of their profession through an approved course at a recognised technical Engineering College. In addition to mechanical training they must possess a good theoretical knowledge of electrical work, so as to be able to design station lighting schemes. A practical knowledge of Stone's train lighting system is essential.

SALARY.—Rs. 550, rising by increments of Rs. 50 to Rs. 1100 per calendar month (with travelling allowance when absent on duty from headquarters), in accordance with the rules in force.

TERMS.—A three years' agreement in the first instance, first-class free passage to Burma, and home again on satisfactory termination of engagement.

The selected candidate will only be appointed subject to his passing a strict medical examination by the Company's Consulting Physician.

Applications (no special form required), giving in chronological order, with dates, the record of the applicant's career, showing the various departments of the railway company in which he was employed and the period of time in each, together with copies only of any testimonials, service certificates, &c. (which cannot be returned), should be addressed to the undersigned not later than Wednesday, the 23rd May, 1923.

THE MANAGING DIRECTOR,
BURMA RAILWAYS CO., Ltd.
199, Gresham House,
Old Broad-street, London, E.C. 2. 2409

Singapore Improvement Trust,

SINGAPORE, STRAITS SETTLEMENTS.

SECOND TECHNICAL ASSISTANT.

REQUIRED for service with the Trust, a SECOND TECHNICAL ASSISTANT, age 25-30, unmarried, on a three years' agreement, with possible extension. He must have had a good general education and technical training as a civil engineer. Preference will be given to candidates who have passed the examination and hold the diploma of the Institution of Civil Engineers or of the Institution of Municipal and County Engineers or of the Town Planning Institute. It will be an advantage if candidates possess personal experience as Assistant Engineers in the working of the British Housing and Town Planning Acts (1575, 1890, 1909 and 1919), viz.:—The Improvement of Congested Dwelling Areas, Re-housing, General Housing Schemes, Land Development for Housing, Re-planning and Land Re-distribution Schemes, Suburban Planning, including the usual work for Surveys, Roads, Lay-outs, and General Town-planning.

The salary will be 6000 dollars for the first, 6480 dollars for the second, and 6960 dollars for the third year, paid monthly in dollars (the currency of the Colony), the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £700. A local transport allowance, subject to variation from time to time as may be sanctioned by the Trust, will be paid. Free first-class passage will be provided, with half-pay during the voyage out. The selected candidate must pass a medical examination.

Applications, stating whether married or single, age, and giving concise dated details of education, training, and experience in general (including war service, if any), with full details of experience in the above class of work, must be accompanied by copies of testimonials and personal references, and be lodged with Messrs. C. C. LINDSAY and PEIRCE, MM. Inst. C.E., 180, Hope-street, Glasgow, Agents to the Trust, not later than Tuesday, 15th May, 1923. 2337

"THE ENGINEER" WANTED.

WANTED, a COPY of "THE ENGINEER" Dated December 26th, 1919.—Address, P5000 The Engineer Office. P5000

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PUBLIC NOTICES

RESIDENT WORKING ENGINEER.

Wanted for King Edward's School and the Convalescent Establishment, Witley, Surrey.

Salary £300 per annum, with

Cottage residence—planned and fitted furniture, fuel and light—valued at £36 per annum.

Age not under 30 nor over 35 years.

Qualifications necessary: Actual experience in the running, maintenance, and repair of a semi-Diesel crude oil generating plant and chloride battery; also a working knowledge of steam cooking, heating, and hot-water plant, plumbing and general maintenance work, and the control and management of staff.

Apply in own handwriting, with particulars of previous experience and copies of three recent testimonials, and giving the date on which the duties could be taken over, to the STEWARD, Bethlem Royal Hospital, Lambeth-road, S.E. 1. 2441

SITUATIONS OPEN

WANTED, a SUPERINTENDENT INSPECTOR, responsible to General Manager for all departments of inspection in Lancashire.—Apply, stating age and salary required, with full particulars of qualifications and experience, to GENERAL MANAGER, Leyland Motors, Limited, Leyland. 2403 A

WANTED on Temporary Work, for Approximately one year, an ASSISTANT ENGINEER or SUB-AGENT, to Take Special Charge of the Ordering, Delivering, and Distribution of all the Materials, &c., required upon Sewage and other large Public Works. State age, experience with contractors, and salary required.—Address, 2449, The Engineer Office. 2449 A

WANTED, SUPERINTENDENT for Electrical Engineering Factory. Applications are invited only from men with actual experience in controlling all departments of a works manufacturing standard machines in quantities on repetition work. Must be disciplinarian and used to working to a manufacturing programme against delivery dates. State age, experience, and salary.—Address, 2411, The Engineer Office. 2411 A

WANTED, SUPERVISOR (Under Chief Engineer) of Plant Maintenance Shop Staff in Chemical Manufacturing Works; highest technical and practical knowledge required. Give experience, with references, stating salary required.—Address, P7424, The Engineer Office. P7424 A

WANTED, the TEMPORARY SERVICES of an ENGINEER well acquainted with Oil Firing of Boilers; one capable of getting out data, &c.—Address, 2457, The Engineer Office. 2457 A

ASSISTANT CIVIL ENGINEER REQUIRED for Hong Kong, age 30 to 45, preferably unmarried; must be experienced in Reinforced Concrete Building, Structural Steel Work, good Draughtsman, and all-round Land Surveyor. Preference given to man trained in Dock and Harbour Work or Waterworks. Salary 325/400 Mex. dollars, according to ability, rising 5) dollars per month annually. Three years' agreement.—Address, J. J., 284, care Deacon's, Leadenhall-street, London. 2416 A

ASSISTANT ENGINEER, Canals; Must Have a good knowledge of Engineering, Surveying, &c., and accustomed to the control of men.—Address, stating age, experience, and salary required, 2450, The Engineer Office. 2450 A

EXPERIENCED MECHANICAL ENGINEER REQUIRED for tropical service; must be fully qualified and good organiser. To Take Charge of Repair Shops and Maintenance of Large Fleet of Lorries. Age limit 36. Salary first year £600. Free passages and quarters.—Write, stating education, training, qualifications, and references, Box J404, Lee and Nightingale, Advt. Offices, Liverpool. 2397 A

MANAGING DIRECTOR for Large Shipbuilding, Engineering and Repairing Yard; good position for experienced man; financial interest not required.—Address, stating experience, 2435, The Engineer Office. 2435 A

MANAGER for Machine Tool Department REQUIRED in London merchant's business. Thorough experience in purchasing and selling and good references essential. State previous experience, age, and salary required.—Address, P7405, The Engineer Office. P7405 A

WANTED by West of England Firm, Experienced MECHANICAL DRAUGHTSMAN, accustomed to Machinery Design and to making full working details; must be quick and accurate.—Address, stating age, experience, and salary expected, 2446, The Engineer Office. 2446 A

WANTED, DRAUGHTSMEN; Must Have Several years' experience of Reinforced Concrete Design.—Apply by letter, stating age, qualifications, and salary required, to the SECRETARY, The British Reinforced Concrete Engineering Co., Ltd., 1, Dickinson-street, Manchester. 2455 A

WANTED, First-class CRANE DRAUGHTSMAN, well up in Steam and Electric Cranes. No one who has not specialised in this class of work need apply. Permanent position for suitable man. State experience and wages required.—SAMUEL BUTLER and CO., Ltd., Grangefield Works, Stanningley, Leeds. 2442 A

WANTED, First-class DRAUGHTSMAN, Fully Conversant with Gasworks and Chemical Plants and capable of detailing complete schemes.—Apply, stating experience and salary required, to R. and J. DEMPSTER, Ltd., Gas Plant Works, Oldham-road, Manchester. 2343 A

WANTED for South of England, DRAUGHTSMAN, used to Centrifugal Pump and Mechanical Filter Work.—Address, 2440, The Engineer Office. 2440 A

A VACANCY Occurs in a Leicestershire Engineering Works for a thoroughly experienced JIG and TOOL DESIGNER, preferably a practical Toolmaker, who has had some years' drawing-office experience on thoroughly interchangeable work of medium size. State age, wage, and full details of experience during the last five years.—Address, 2447, The Engineer Office. 2447 A

BRITISH THOMSON-HOUSTON CO., Ltd., Willesden.—DRAUGHTSMEN, with first-class experience of Switchgear Work, WANTED; must be really first-class men.—Write, stating age, experience, and salary required, to CHIEF DRAUGHTSMAN, The British Thomson-Houston Co., Ltd., Willesden, N.W. 10. 2383 A

DRAUGHTSMAN, Experienced Senior, REQUIRED for Steel Railway Carriage and Wagon Work.—State experience, salary required, &c.—Apply, CAMMELL LAIRD and CO., Ltd., Railway Carriage and Wagon Works, Nottingham. 2324 A

DRAUGHTSMAN, Mechanical, Experienced in Jig and tool.—Address, stating age, experience, and salary required, 2362, The Engineer Office. 2362 A

DRAUGHTSMAN REQUIRED for Railway Carriage and Wagon Work, fully experienced.—Apply by letter only, stating age, experience, and salary, METROPOLITAN CARRIAGE CO., Saltley, Birmingham. 2448 A

DRAUGHTSMEN REQUIRED for Switchboard Lay-outs. Good positions for the best type of men.—Address, stating full particulars and salary required, 2384, The Engineer Office. 2384 A

DRAUGHTSMAN, Senior, for Large A.C. Machines and Rotary Converters.—Address, stating age, experience, and salary required, 2314, The Engineer Office. 2314 A

DRAUGHTSMAN WANTED for Large Engineering Works in Bombay; age not exceeding 30; single man preferred.—Write, giving full particulars of career, to "DRAUGHTSMAN," c/o. Deacons, Leadenhall street E.C 3. 2453 A

SITUATIONS OPEN (continued)

DRAUGHTSMAN WANTED; Experience in the Design of Automatic Machinery essential. Also DRAUGHTSMAN, experienced in the Design of Jigs Tools, and Fixtures used in connection with the manufacture of ordnance.

Applicant to state previous experience, age, &c., and to supply references.

Address, 2399, The Engineer Office. 2399 A

EXPERIENCED MECHANICAL DRAUGHTSMAN, with general engineering experience, REQUIRED for works in London area.—Address, stating age, experience, and salary required, 2444, The Engineer Office. 2444 A

FIRST-CLASS MECHANICAL DRAUGHTSMAN for General Factory and Power Station Work. State age, full particulars of experience.—Address, 2436, The Engineer Office. 2436 A

FIRST-CLASS ROLLING STOCK DRAUGHTSMAN REQUIRED. Experience in Tramcar and 'Bus Work preferred. State experience and salary required.—Address, 2428, The Engineer Office. 2428 A

JIG and TOOL DRAUGHTSMAN REQUIRED, with good experience on Commercial Motor Vehicle manufacture. Temporary post. London district, £5 per week.—Address, 2422, The Engineer Office. 2422 A

FOUNDRYMEN Wishing to Improve their Position should read Greave's "FOUNDRYMAN'S EDUCATOR," giving mixtures of non-ferrous metals and alloys, irons and foundry productions. Post free 6s.—GREAVES, Harefield Hall, Heywood. P7392 A

ESTIMATOR REQUIRED, Shop Experience Essential; 30 miles north of London. State age, qualifications, salary required.—Address, 2454, The Engineer Office. 2454 A

STOREKEEPER ACCOUNTANT REQUIRED for tropical service; must be used to handling and recording of large stocks, engineering stores, motor spares, &c. Salary £400 per annum. Free passages, quarters.—Write, Box F491, stating education, qualifications, and references, Lee and Nightingale, Advt. Offices, Liverpool. 2398 A

SITUATIONS WANTED

ADVERTISER (24), Prospective B.Sc., DESIRES to gain Surveying and Office Experience, or would consider any other suitable EMPLOYMENT offering prospects; 4 yrs. apprentice (mech. eng.), 3½ yrs. full-time tech. college, L. Matric., Inter. B.Sc. (Eng.); neat draughtsman, and conscientious worker; small wages.—Address, P7412, The Engineer Office. P7412 B

ADVERTISER (24, Single), 4 Years Engineering College, DESIRES START, any capacity.—V. E. W., 34, Hart-road, Dorking. P7440 B

AN ENGINEER, Young (30), DESIRES POSITION as Assistant to Chief Engineer or Works Manager; thorough workshop and electrical training; internal combustion engines, erection of plant, &c.; good commercial experience; good refs.; salary about £350.—ENGINEER, 58, Worlingham-road, London, S.E. 22. P7447 B

COMMERCIAL MANAGER, Lately Returned from America, DESIRES POSITION in London or South; varied and sound experience, economic administration, production, labour-saving, sales; capable and able to obtain contracts and results; conclusive references.—Address, P7439, The Engineer Office. P7439 B

DESIROUS OF CHANGE.—ENGINEER'S MACHINE SHOP FOREMAN, with 21 years' experience of motor car engineering and the manufacture of small engineering parts; good organiser and disciplinarian; also used to laying out the various operation of parts and fixing of prices for same; sound knowledge of automatic machines, turret and capstan lathes. Willing to travel. Splendid references.—For further particulars address, P7446, The Engineer Office. P7446 B

ENGINEER, A.M.I.C.E., Age 29, REQUIRES TEMPORARY APPOINTMENT. Good experience home and abroad, design and construction waterworks, reinforced concrete buildings, bridges, wharves. Highest refs.—Address, P7415, The Engineer Office. P7415 B

ENGINEER, Mechanical Running Maintenance, experienced all manner of machinery, also refrigerating, own repairs, DESIRES SITUATION, London area. Available now.—Address, P7419, The Engineer Office. P7419 B

ENGINEER, Young, DESIRES MANAGEMENT of SMALL WORKS or Assist. to Consulting Engineer; salary about £400.—Address, P7443, The Engineer Office. P7443 B

ENGINEER (40 Years), F.R.S.A., M.I. Mech. E., M.I. Mar. E., civil, mechanical and marine experience, 20 years' experience in South America, 12 years in present position as manager of concrete works and dry dock, DESIRES responsible POSITION abroad.—Apply, E., 703A, Fulham-road, London. P7421 B

GENTLEMAN, Under 40 Years of Age, at Present managing director of large old-established engineering concern manufacturing both heavy machinery and light precision work, is PREPARED to RESIGNER SIMILAR APPOINTMENT; extensive experience of modern manufacturing methods. Total emoluments must exceed £2000 per annum.—Address, P7438, The Engineer Office. P7438 B

INSPECTION DEPT.—Keen MAN, 16 Years' Exp., thorough knowledge modern machine shop and inspection methods (automobile and electrical); Vickers, Rolls-Royce, and Vauxhall experience.—Address, P7258, The Engineer Office. P7258 B

JOHN HEATH, Cudworth Lodge, Newdigate, Surrey, having 21 years' experience of interchangeable production as chief designer, purchaser and works superintendent, &c., accustomed to control large staffs, OFFERS SERVICES in similar capacity or as London Representative. Inquiries solicited. P7227 B

MECHANICAL ENGINEER (42) DESIRES POSITION. Experience as manager of general engineering business, including pattern shop, foundry, machine shop, smithy, and boiler shop. Used to correspondence, interviews, travelling, and all office routine. —Write No. K317, Keith and Co., Advertising Agents, Edinburgh. P7402 B

MECHANICAL ENGINEER, Degree M.E., DESIRES return ENGAGEMENT for India. Nine years' experience designer and engineer, American steel and allied companies, blast-furnaces, open-hearth furnaces, rolling mills, buildings; three years' recent experience engineer large Indian steel company. Present engagement development engineer prominent firm American engineers.—Reply, J. V. McCartney, 4554, Malden-street, Chicago, Ill., U.S.A. 2371 B

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For continuation of Small Advertisements see page 3

Admiralty Engineering Laboratory at West Drayton.

ALTHOUGH the Admiralty Engineering Laboratory has only been in existence a little over six years, the results so far achieved have contributed in a notable manner to the progress of certain branches of naval engineering, while, without any prejudice to naval interests, valuable technical information has been made available for the use of commercial engineers.

We therefore particularly welcome an opportunity of describing the work of the laboratory and some features of its equipment, and would tender to the Lords Commissioners of the Admiralty and the Engineer-in-Chief, Vice-Admiral Robert B. Dixon, C.B., our appreciation and thanks for the facilities placed at our disposal in preparing this article and illustrating it.

HISTORY AND BEGINNINGS.

The laboratory was initiated early in 1917 as a result of the urgent need experienced by the Board of Invention and Research for an establishment in which schemes considered to be important for the development of the naval engineering service could be experimentally tested and proved. Its first home was in a part of the Goldsmiths' Company's extension to the City and Guilds Engineering College at South Kensington, which was placed at the disposal of the Admiralty by the Delegacy of the College. But early in 1920 the space occupied by the laboratory at South Kensington was urgently required by the City and Guilds Engineering College for its own work, and arrangements were accordingly made to transfer the laboratory to West Drayton, in Middlesex. The buildings now occupied were taken over by the Admiralty during the war, and they were originally the Sonic Works where Mr. George Constantinesco carried out his experiments on wave power transmission. The factory became vacant in April, 1920, and after some minor structural alterations had been completed the Admiralty Laboratory plant was transferred at the end of July. An electrical section was added in August, 1920, which, for administrative purposes, is an integral part of the laboratory, although its programme of work is under the control of the Admiralty Director of Electrical Engineering, whereas the Engineering Laboratory proper is under the personal direction of the Engineer-in-Chief of the Fleet.

A short reference to the laboratory staff may perhaps be made at this point. The Superintendent is a naval engineer officer, but all the other members of the staff are civilians. The administration and control of the work in progress is directed by the Superintendent, Engineer-Commander H. B. Tostevin, D.S.O., R.N. The work of the drawing and designing office is directed by the chief designer, Mr. A. W. Newman, while the experimental trials and the running of the workshops, together with general industrial work in and about the laboratory, is supervised by Mr. J. Aitken, the chief testing engineer. The more recently added metallurgical section is under the supervision of the chief metallurgist, Dr. O. F. Hudson, and the electrical section is directed by an electrical engineer with the assistance of a small designing and laboratory staff.

A large house, standing in its own grounds adjoining the establishment and belonging to it, furnishes office accommodation for the administrative, clerical and drawing-office work, and also enables certain of the finer metallurgical work to be carried on free from disturbance arising from vibration which, necessarily accompanies the running of machinery and the testing of engines.

THE LABORATORY EQUIPMENT.

For purposes of description the laboratory may be conveniently grouped into three main sections—the small engine-testing bay; the workshops and the special section devoted to the testing of materials; and the testing bay for the large engines. In the illustrations which form our Supplement, we show views of these sections together with the engines. The small engine-testing bay is shown in Fig. 1. On the extreme left will be seen a standard four-cylinder paraffin engine coupled direct to an electric generator. A large number of engines of this and similar types are now in use in the Navy, and the tests which have been made have contributed towards greater reliability of operation and economy of working with this class of prime mover. Alongside the paraffin engine is a single-cylinder hot bulb engine of the Bolinder type developing 40 brake horse-power. It is equipped with a Froude water brake and the usual testing appliances. To the right of the Bolinder engine is a 30 brake horse-power single-cylinder four-cycle Diesel engine, which has been devoted especially to testing various fuels. It runs at a relatively high speed, developing its full power at 375 revolutions per minute, and it has a 9in. diameter cylinder with a piston stroke of 12½in. In addition to testing various classes of Texas and shale oil, interesting experiments have been carried out on it with palm oil, enabling comparisons between these different fuels to be drawn. The special arrangements which were made for the trials with palm oil, including the steam-heated fuel tanks, can be seen in the illustration, Fig. 1. It is interesting to note that no difficulties have been experienced in using palm oils of various qualities, and it was not necessary to alter the general engine details. It is hoped that in the near future it will be possible to publish the results of these experiments.

A somewhat unusual engine, which is not illustrated, is the compound internal combustion motor, built to the designs of Mr. Ricardo, by Peter Brotherhood and Co., Limited. A number of preliminary tests were made with it running on gas when it was first installed at South Kensington. These experiments are in abeyance for the time being, but in view of the renewed interest displayed in the compound oil engine, it is possible that they may be continued.

Among the smaller plant in this part of the laboratory is the special apparatus which was designed for investigating the problem of fuel injection. An account of the work done by the laboratory on this subject was given in a paper read before the North East Coast Institution of Engineers and Shipbuilders by Eng. Commander C. J. Hawkes, R.N. (retired), under whose superintendence the laboratory was initiated. Further experiments have now been made with the improved apparatus, and have given important information concerning the problem of fuel injection for high-speed engines of large power. One particular investigation was carried out in order to determine the influence of temperature on the "time lag" which occurs between the moment of injection and the moment when rise of pressure begins. A series of tests are now being made in which the character of the jet is altered in definite ways so as to vary such conditions as the degree of atomisation and depth of penetration. Interesting results have already been obtained, and the experiments are to be continued. Other detailed work has also been done on problems connected with piston cooling at high speeds and the evolution of a reliable and accurate type of indicating gear.

WORKSHOP AND TESTING OF MATERIALS.

The workshop section of the laboratory is illustrated in Fig. 2. It will be noted that the equipment includes a wide range of machine tools conferring the important advantage that details of the engines may be modified during the course of an experiment, and any necessary experimental apparatus made in the laboratory itself. On the left of the workshop a part of the main building has been reserved for the testing of materials and for metallurgical work. This section is fully equipped for the analysis of metals and alloys and also for metallographic work and the study of heat treatment problems. The testing machines include those used for tensile, compression, impact, and hardness tests, while special machines have been evolved to assist the work in hand. Among such apparatus we noted a machine on which bearings may be run under conditions approximating to those obtaining in actual service, more especially with a view to overcoming the difficulties attending the use of gun-metal bushes for the gudgeon pins of large aluminium alloy pistons. A great deal of the metallurgical work has been devoted to the investigation of the properties of the aluminium alloys which are used for these pistons. The suitability of carbon and stainless steels for engine liners has also been considered, and liners have been tested under running conditions. In addition to the metallurgical work directly appertaining to the experiments conducted in the laboratory, special problems concerned with the use and the experience obtained with materials in naval service have been investigated.

The large engine testing bay is one of the most important sections of the laboratory, and the internal arrangements are shown by the illustration we reproduce in Fig. 3. At the present time four engines are accommodated in this bay. Facilities for dismantling and inspection have been provided by installing an overhead 5-ton travelling crane.

The four engines referred to are as follows:—

Doxford Opposed Piston Engine.—Originally built by William Doxford and Sons as an experimental submarine unit, this is an example of the opposed piston type of two-cycle engine with which the firm's name is associated, and is illustrated in Fig. 4. It has a single cylinder with a diameter of 14.5in. and a combined stroke of 28.3in., and develops its full power of about 300 brake horse-power at a speed of 300 revolutions per minute. After a series of tests it has been adapted for driving an electric generator for power purposes, for which it is now used. Experiments made with aluminium alloy oil-cooled pistons fitted with "incandescent" crowns have thrown light on the erosion which takes place on these parts, and all-aluminium alloy pistons have recently been fitted with a view to testing their suitability for engines of this type.

Unit Engine.—Built by Ruston and Hornsby, Limited, to designs based on the Vickers submarine engine. It is shown in the foreground of Fig. 3. This motor has a single cylinder 14½in. in diameter by 15in. stroke, and develops its full rated power at 380 revolutions per minute. The Vickers type of solid injection fuel valve is fitted. The results of tests made with this unit have enabled improvements and modifications to be made to parts of standard submarine engines, and trials with Texas and shale oils have indicated the best form of fuel cam and spray nozzle. Extended runs have been made with an uncooled aluminium alloy piston under heavy continuous load with good results, and pistons of a similar design have since been fitted to existing submarine engines with a view to testing this type of piston under actual service conditions. A series of tests have been made on this engine in order to determine the most suitable arrangement of certain engine details for the purpose of assembling standard submarine engines in such a way as to form Diesel driven electric generating sets. In service these engines must be capable of developing a constant speed from no load up to full power of 50 brake horse-power per cylinder.

Digit Engine.—This is a 300 brake horse-power Admiralty Engineering Laboratory engine constructed at Chatham Dockyard. It is shown in the illustration reproduced in Fig. 5. It, too, has a single cylinder of 20in. diameter and 20in. stroke, and develops its full power at a speed of 390 revolutions per minute. The data resulting from tests which have been made have proved of considerable service in designing engines which are now being built.

Single Acting Two-stroke Engine.—The illustration reproduced in Fig. 6 shows a two-stroke single acting engine constructed by J. and S. White and Co., Limited, of Cowes, to designs prepared by the laboratory. It develops 400 brake horse-power at 390 revolutions per minute. A stepped piston supercharging device has been embodied in the design and preliminary tests have already been run.

Double-acting Two-stroke Engine.—Designs have been prepared for and construction is approaching completion of a large two-cycle double-acting experimental engine, which, it is hoped, will shortly be available for laboratory testing, and will be installed in a special building which is now in course of erection and equipment. This engine will run at a high speed and will embody several improvements suggested by experimental results. Supercharging arrangements are provided for. It is expected that the horse-power developed per cylinder will be considerably more than that which it has been found possible to obtain hitherto with engines of similar cylinder dimensions either of the four-stroke or two-stroke double-acting type. If successful, this engine will greatly increase the range of the application of high-speed Diesel engines to naval problems.

WORK OF THE LABORATORY.

It may be of interest to review briefly the work done by the laboratory since its inception.

In November, 1915, a question relating to the material and design of the pistons for submarine oil engines had been referred to the Board of Inventions by the Engineer-in-Chief of the Admiralty, and the decision of the Sub-Committee on Internal Combustion Engines to build an experimental engine for the purpose of elucidating the problems presented by the inquiry, influenced in a large degree the early work of the laboratory and its subsequent development. In order to avoid delay, this experimental unit was constructed as far as possible from standard submarine oil engine parts. The designs for the special parts, such as the piston, the connecting-rod, and the bedplate, were, however, prepared under the direction of the Board, and the engine was assembled and built in the works of Ruston and Hornsby, Limited, at Lincoln. Preliminary trials were made in July, 1916, and the new features, the aluminium alloy piston and the I-section connecting-rod—the previous connecting-rods for standard submarine engines were round—were shown to be satisfactory and reliable in operation. After some small alterations the engine was transferred from Lincoln to the Admiralty Engineering Laboratory and the trials were continued in September, 1917.

By this time a small designing and testing staff had been got together and the progress of the experimental plant and the assembling of the necessary workshop machinery was well advanced. Detailed particulars of the various tests made on this engine were given in a paper read before the 1920 summer meetings of the Institution of Naval Architects* by Engineer-Commander C. J. Hawkes, R.N. (Ret.). Briefly summarising the results of the tests made, we may refer first to important information which was gained as to the capacity of the engine piston to withstand mean indicated pressures up to 140 lb. per square inch. The speeds during the trials varied from 380 revolutions per minute, which was the normal speed of the engine up to 500 revolutions per minute. Obturator rings were also tested with promising results. Further, a series of combustion experiments was carried out and eminently satisfactory results were obtained both with mechanical and air injection, while progress was made in the direction of reducing a tendency to smoke, which had been observed in the standard type of submarine engine working with mechanical injection.

Early in 1918 several British firms were asked to produce designs of single-cylinder experimental engines developing from 300 to 400 brake horse-power. Some of these engines were built, and we shall have occasion to refer to them later. About the same period the laboratory designing staff prepared

* See THE ENGINEER, July 23rd, 1920.

preliminary drawings for an experimental four-stroke cycle single-cylinder engine of 300 brake horse-power, which was built at Chatham Dockyard. This engine was described and illustrated in THE ENGINEER for July 23rd, 1920. Owing to space considerations it was decided to make a square engine with a 20in. diameter piston and 20in. stroke, which could develop its full power at 390 revolutions per minute. This speed corresponded to a piston speed of 1300ft. per minute, which was an advance on previous practice. Although the drawings of this engine were finally completed before any information was available as to the German designs, it is of interest to note that the principal dimensions of the engine designed by the laboratory staff corresponded very closely with the dimensions of the German engines, the cylinder diameter of the latter being 20.8in. with a stroke of 20.8in., each cylinder developing approximately 300 brake horse-power when the engine was running at 300 revolutions per minute. The tests made with this engine are described in Engineer-Commander Hawkes' paper previously referred to. Air injection was used and satisfactory running with mean indicated pressures of 130 lb. per square inch was achieved. This series of experiments indicated that for mean pressures higher than 130 lb. per square inch some form of supercharging would most likely have to be used. The weight of the reciprocating parts calculated on the basis of pounds per square inch of piston area was considerably less than that for a German engine designed for similar speed and output. A further paper, also by Commander Hawkes, which was read before the North-East Coast Institution of Engineers and Shipbuilders on November 26th, 1920, deals with the experiments made with a special apparatus designed to investigate the problems connected with the burning of fuel oil in a Diesel engine cylinder. Particulars of the various types of spraying nozzles used, their arrangements, and the cylinder pressures are given, and the phenomenon of detonation, is referred to. Further reference to the work of the laboratory was made by Engineer Vice-Admiral Sir George Goodwin, K.C.B. (Ret.), in his paper on "The Development of Diesel Engines for Naval Purposes," which was read before the Institution of Engineers and Shipbuilders in Scotland on April 18th, 1922. After giving an account of the earlier engines that were tried in the Navy, the development during the war period is described and a brief account of the work of the laboratory is given.

In the present article it has only been possible to touch upon the main features of the engines and equipment at the laboratory, and certain details of the work have of necessity been omitted. Sufficient has been said, however, to indicate the main trend of the work and to show the direction in which new development is proceeding. The evidence of the laboratory experience clearly shows that it is now possible to realise the maximum power in Diesel engines of given dimensions and types, while at the same time greatly reduced outputs are possible without serious modification of details or increased complexity. The full-scale experiments which have been carried out over a wide range with the single-cylinder units have confirmed the great importance of carrying out research work on a large scale. Small-scale experiments give, of course, a certain amount of information, but it is only when designs are tested on a large scale that results may be applied with any measure of confidence to actual engines. Even successful results obtained from full-scale tests with single-cylinder units may not be accurately reproduced when the same conditions are applied to multi-cylinder engines, and this has been kept in view in designing the new two-stroke double-acting experimental engine for the laboratory, which will be of the multi-cylinder type.

We have often urged the great importance of the internal combustion engine for naval work, and it is well to remember that engines designed for such work present a different series of problems from those which we associate with engines for the mercantile marine and land purposes. It must be admitted that at the beginning of the war our country was undoubtedly behind some of the continental nations in its knowledge and development of the heavy oil engine, but the work of the Admiralty Engineering Laboratory has in the last few years removed this reproach, and with the continuation of the present experimental work there is little doubt that in matters relating to Diesel engines, as in other spheres, the British Navy will continue to maintain its prestige. Before the war and during its course the Navy was much indebted to private firms and engine builders for data obtained from experiments on new types of engines. In the present circumstances when rigid economy is necessary and naval orders are few it is satisfactory that, while maintaining a lead in internal combustion engine construction, the Admiralty is in a position to publish in papers read from time to time before engineering institutions, results of laboratory investigations which are valuable for commercial purposes, and may be of considerable use to the engine builders of the country.

THE Transvaal gold output during March was 761,586 oz., valued at £3,331,939 on the basis of 87s. 6d. per ounce, compared with the February figures of 704,970 oz., valued at £3,084,244 on the same basis. Natives employed at the Transvaal gold mines number 181,573, compared with 182,983 in February.

The Gas Turbine in Theory and Practice.

No. II.*

PRACTICAL EXPERIENCE WITH THE GAS TURBINE.

OF all the isolated and fragmentary work which has already been done on the gas turbine, very few designs, and even fewer test results, have actually been made public. Scanty and often inconsistent as these figures are, they seem destined, however, to form, in their own way, milestones on the road of development which may eventually come to be regarded as being of historical interest. It so happens that these actual tested installations have really provided a good deal of useful information, even though much of it is of a negative character. It is important to notice that they have certainly demonstrated that with the possible up-to-date improvements in design and material, and with some extension of the working conditions, thermal efficiencies superior to those of good steam practice can be obtained even to-day without any particular difficulty. Efficiencies equal to, or even exceeding, the best oil engine practice, are probably obtainable in theory, though not within the same cycle limits. They are not in sight to-day and are unlikely to be for some years, mainly owing to the lack of material suitable for withstanding the very high temperatures which such efficiencies demand. Though far from impossible they will demand vastly better material than any that was employed in these early machines or is even available to-day. Thus, for instance, more than one of the first experimenters boldly adopted the use of platinum, which has a melting point of about 3200 deg. Fah., in an effort to obviate the difficulty of obtaining a suitable high temperature nozzle. The use of such an exceptionally rare and expensive element, impossible except as a laboratory experiment, is quite unnecessary nowadays for the purpose of obtaining moderate efficiency, and is only mentioned in order to indicate that even such solutions have been attempted in order to get over the difficulty of the very high initial temperature.

In Table I. are given the leading particulars of the various gas turbines which have been submitted to test, and of which the results have been made public. Table II. contains a summary of the latter. Beyond the records contained in these two lists, there is very little more data available at all, although Table I. is far from being a complete list of all the gas turbines made, for others have been constructed at various times by Fullagar, Garuffa, the General Electric Company, Holzwarth, Körting, Stolze, Zsellyi, &c., and by others in Italy, Sweden, Switzerland, the United States, and elsewhere. Incomplete and unsatisfactory as the information is, much of it has pointed out very clearly the directions in which progress can be made. Before, however, discussing the theory of the gas turbine, reference may be made to the practical results hitherto obtained.

(1) *Armengaud and Lemale.*—Armengaud, like many others, commenced his experiments by using an old Laval steam turbine, to which he attached a cast iron combustion chamber lined with carborundum. Into this, pre-heated paraffin was injected at about 100 lb. pressure through an atomiser, air being supplied through a concentric annular tube round the spray at about 75 lb. pressure above atmosphere. The outside of this casting was water-jacketed, and the vaporised water therefrom was led into a prolongation of the combustion chamber in order to reduce the temperature of the mixture before it entered the cast iron nozzle. No direct statement was ever made by the authors in regard to their work, but descriptions were published in *Cassier's Magazine* in 1907–8. After experimenting with the first small machine, which was properly tested for consumption, a second machine, designed for 400 brake horse-power, was built. Unfortunately, hardly any test data is available for the latter. It was an installation, however, of considerable interest, because for it was designed as a Rateau multiple-disc air compressor, with twenty-two fans in series, disposed in three separate cylinders; this was the original turbo-compressor from which all the later machines of this type have been developed. An efficiency of 65 per cent., compared with the isothermal, was obtained with this unit. Another special feature of this second turbine was the internal water-cooling of the rotor, and of each individual blade. It is difficult to reconcile the published figures for the number of nozzles given for both turbines either with the published photographs of the second machine, or with the given designs of the combustion chambers, of which the second machine, certainly, only possessed one. In the case of the first turbine, trouble was experienced with the carborundum lining, which tore out, and passing into the turbine, damaging the blading—an accident which should prove a warning in future designs. Working from the heat drop in Table II., the velocity of the mixture leaving the nozzle would appear to be about 1460ft. and 1900ft. per second in the two cases, giving a ratio of blade speed to gas speed of about 0.36 in each. With the single-row wheel, this should give a blading efficiency of about 74 per cent.; it is much too high a value for a two-row velocity compounded wheel, and the efficiency of the latter, neglecting wheel friction and nozzle loss, would fall to below 55 per cent. It is rather unsatisfactory to attempt to analyse trial data of such a meagre nature, but from the recorded data as published, one is led to suspect the absolute accuracy of the temperature measurements, so that the efficiency obtained is still somewhat problematical.

Torpedo Turbine.—The Société Anonyme des Turbomoteurs, which built the Armengaud turbines, also constructed a gas turbine of 120 horse-power which was intended for the propulsion of torpedoes. Certain very special factors are involved in this application which render the broad idea of a gas turbine for this purpose rather an attractive one. In the first place, the necessary duration of the run is very short; in the second, economy is not of very vital importance. The exhaust pressure needs to be high in order to overcome the resistance of the head of water above the submerged torpedo, and in this case was as much as 20 lb. This machine was only arranged for a run of 80 sec., and both this and the power are much too small for the modern 21in. torpedo. A range of at least 12,000 yards is necessary to-day, and at a mean speed of 30 knots a run of some 12 min. is involved. The air supply is, of course, pre-compressed in the ordinary manner. The turbine, complete with tanks and fuel for the 80 sec. run, weighed 560 lb. Deducting the 87.5 lb. of paraffin, air and water used, this shows a net weight of just under 4 lb. per brake horse-power—not a bad figure considering that the turbine was built many years ago.

As it is intended to deal with the Holzwarth turbines* in discussing the constant-volume cycle and explosion turbines separately, reference to the Karavodine turbine will be deferred. This type worked in a cycle in which there is no pre-compression and in which the heat addition takes place with both pressure and volume changing. Machines of this type are only practicable in very small units; they are very inefficient, but exceedingly simple. It is, however, difficult to conceive what useful purpose they can be applied to in view of the greatly superior efficiency of the small petrol motor.

Rateau Exhaust Turbine.—This machine cannot strictly be classed as a pure gas turbine; it is really a waste-heat engine, which derives its advantages and applicability from very special conditions. It was fully described in Professor Rateau's paper† read to the Paris meeting of the Institution of Mechanical Engineers last year, and while it is unnecessary, therefore, to repeat a full description, certain features demand notice because they go to prove very clearly indeed how the growth of knowledge in respect of design and material has developed to the great advantage of the internal combustion turbine since the time of Armengaud's experiments. Owing to the diminution in the density of air with increase of altitude, the falling off in air, *i.e.*, oxygen, supply to the carburetters of aviation engines causes a rapid reduction in power as the machine ascends, and, hence, in speed either on the level or in climbing; it is this which limits the height of ceiling in aeroplanes. Experience of this effect had led to many suggestions for super-charging carburetters, but little was done till 1917 when a turbine operated by the exhaust gases from a 175 horse-power aero engine was used to drive a fan for restoring the ground level atmospheric pressure when the engine was tested under conditions representing variations of altitude up to normal heights. During these trials, the turbo-compressor was made to revolve up to 53,000 revolutions per minute, giving a peripheral speed of no less than 2200ft. per second at the tips of the compressor blades, which were 9.5in. in diameter. Drawing from a reservoir, and compressing to atmospheric pressure, this single-fan compressor maintained a vacuum of 24in. In other figures it had a compression ratio of more than 4.5. For the 300 horse-power Breguet engine, the single-row turbine wheel is 18 cm. in diameter, and the compressor fan 24.2 cm. The revolutions at altitude are normally from 25,000 to 30,000 per minute, giving a peripheral speed for turbine and compressor blade tips of 850ft. and 1140ft. per second respectively. The turbine rotor is made of tungsten tool steel, and the compressor fan of nickel steel. The conditions under which this apparatus works are exceptionally severe. The centrifugal force is very high indeed, and while the turbine rotor is required to revolve in gas at about 1200 deg. Fah., the compressor fan is subjected to very low temperatures indeed at high altitudes, sometimes reaching to 100 deg. Fah. below zero. The result is that at one end of a shaft only 33 cm. long between bearings, the metal is heated almost to redness, while the other is in a temperature conducive to extreme brittleness in the case of ordinary materials. Professor Rateau claims that both turbine and fan each have an efficiency of over 50 per cent., the actual overall efficiency being 27 per cent. The remarkable feature of this installation is the very high blade speed used at a temperature at which the strength of all metals is very considerably reduced, and at one far in excess of any other gas turbine. The very small size of the rotor is in its favour; the production of steel forgings several

* No. I. appeared May 4th.

* See THE ENGINEER, December 8th, 1911.
† See THE ENGINEER, November 3rd, 1922.

feet in diameter, where this is merely in inches, is a very different matter if the same conditions of temperature and stress are simultaneously imposed.

The two tables reveal various points of interest and require some explanation. Apart from the regrettable fact that no British machine finds place, the first feature is the date column. It would be very wrong to attempt to base any opinion on the future of the gas turbine without taking this into account, and with it the extent of the knowledge of turbo-mechanics at the time. The first three of these machines are all of the super-atmospheric constant-pressure, mixed fluid type. Armengaud's first machine was a makeshift—a converted steam machine using, apparently, the original steam nozzle, which was, of course, designed for a much higher expansion ratio than the gas mixture required—a supposition that is borne out by the apparent superheating of the exhaust. Brief analysis of the performance with the mixture used and with assumed variations of the water content shows that the latter was far too high, as well as the fact that the radiation losses were excessive. The compression ratio was too low for good results, only admitting, at best, of less than 40 per cent. absolute thermal efficiency, and much superior efficiency would have been obtained in this same machine had it been worked on a sub-atmospheric cycle. Again, the blade speed was also much too low; a higher blade speed and correspondingly greater heat drop would have admitted of higher absolute thermal efficiency being obtained even on the super-atmospheric cycle used. The former was increased in the second machine, but the water content was again very excessive—more so than in the first turbine—and the temperature drop in the nozzle was too low to give a sufficient gas speed for a two-row velocity compounded turbine running at 695ft. per second blade speed. The Rateau compressor, although it gave a good efficiency considering that it was the first of its type, absorbed far too much work proportionately—the turbine efficiency being low—requiring, as it did, nearly half the total output of the gas turbine, and thereby reducing the ratio of positive to negative work. Great improvements, moreover, could be effected to-day in the design of the combustion chamber, the radiation losses from which were serious. Under modern conditions, with a rotary compressor efficiency obtained in daily work to-day, with reduced radiation loss and with extended working conditions, an efficiency of nearly double the 9.5 per cent. should be easily realised, because when an inefficient positive motor drives an inefficient negative one the amount of surplus work available falls very rapidly indeed. The ratio of positive to negative work in the cycle is of vital importance. If this be, say, 2.33, as it is with adiabatic expansion and compression on the standard air cycle, then the surplus work becomes zero when the product of the thermo-dynamic efficiencies of turbine and compressor falls to 0.43, which even admits of each having 65.5 per cent. An increase of each to 70 per cent. gives an overall efficiency of 14 per cent., while 75 per cent. apiece increases the latter to 31 per cent. The same overall efficiency as the last is obtained with 90 per cent. efficiency of compression—not an unusual figure in reciprocating compressors—even if the turbine efficiency remains at 65.5 per cent. These efficiencies, of course, are far below those of heavy oil engine practice. Our next article will be devoted to their consideration in detail.

TABLE I.—*Particulars of Internal Combustion Turbines.*

Inventor.	Maker.	Date.	Type of turbine.	Approximate B.H.P.	R.p.m.	Diameter of rotor, inches.	Blade speed, ft. p. min.	Type of rotor.	No. and diam. of nozzles.	Remarks.
Armengaud and Lemale (A)	Société des Turbomoteurs, Paris	1903–4	Constant pressure mixed fluid (air, paraffin, steam). Old Laval turbine used	Actual 25.5 ex compressor	20,000	6	525	Laval single wheel steam pattern	Four 8.7 mm.	Incandescent platinum wire used for first ignition. C.I. combustion chamber lined with carborundum and water jacketed. See *Cassier's Magazine*, 1907 and 1908.
Armengaud and Lemale (B)	Société des Turbomoteurs, Paris	1905–6	C.P. mixed fluid	Designed 400	4,250	37.5	695	Single wheel 2-row velocity compounded water-cooled wheel and blades.	Thirty-three 10 mm.	Trials abandoned owing to M. Armengaud's death in 1909. See *Cassier's Magazine*, 1907 and 1908.
? Torpedo turbine	Société des Turbomoteurs, Paris	?	C.P. mixed fluid	120	15,000	12	790	Single wheel 2-row velocity compounded	—	Designed for use in torpedoes, needs only 80 seconds' run. Whole plant, including turbine, combustion chamber and water tank of 2½ gallons, occupies 18 cubic in. Turbine and combustion chamber weigh 160 lb.
Karavodine	? Paris	1908	Open chamber explosion type, no pre-compression	1.6	10,000	6	260	Laval single-wheel steam pattern	Four explosion chambers, nozzles 16 mm.	See *Cassier's Magazine*, 1908. Similar turbine built by Zsellyi's at Buda Pesth in 1913. Combustion chamber volume = 230 cub. cm. each.
Holzwarth (A)	Brown, Boveri and Co., Mannheim	1908	Constant volume, single fluid	Designed 1000, actual 450	3,000	39	520	Single-wheel 2-row velocity compounded	Ten explosion chambers	Vertical shaft design. This machine appears to have been rebuilt, as the first design given in Holzwarth's book, 1911, is markedly inferior in constructional detail to that given in Professor Schuls's paper in 1921.
Holzwarth (B)	Thyssen and Co., Mulheim	1921	Constant volume, single fluid	Designed 500	3,000	43.3	565	Single-wheel 2-row velocity compounded	Six explosion chambers	Horizontal shaft design. See Schuls, *Elektrotechnische Zeitschrift*, July 28th, 1921. Ordered by Prussian State Railways for electric supply.
Rateau	Sautter Harlé and Co., Paris	1917–20	Exhaust turbine using gases discharged from petrol aero-engine	50	27,000	7.3	850	Single-wheel Laval type	—	See Rateau's paper, Inst. Mech. E., Paris, 1921. Machines of this type have also been built by the G.E. Company, Schenectady. Turbine drives 10½in. diameter fan for supercharging carburetters. Total weight of turbine and fan complete 50 lb.

TABLE II.—*Results of Trials of Internal Combustion Turbines.*

Inventor.	Combustion chamber.		Exhaust.		Fuel used.	Consumption, lb. per B.H.P. per hour.	B.H.P. developed.	Reputed brake thermal efficiency.	Air compressor.		Remarks.
	Pressure, lb. per sq. in. (gauge).	Temperature, ° F.	Pressure, lb. per sq. in.	Temperature, ° F.					Type.	Delivery pressure, lb. per sq. in. (gauge).	
Armengaud and Lemale (A)	Air 75.	3270 in C.C., reduced to 1100° with steam addition on entering nozzle	Above atmosphere	930	Air, water, paraffin	28.5 11.7 1.5	25.5 (not allowing for compressor)	9.5 neglecting compressor; about 40 including compressor.	Piston	75	With fuel cut off, and using air only, 10.5 H.P. were developed with 2000 lb. of air per hour, supplied at 200 lb. pressure. Mixture by weight = air 19.0, water 7.7, paraffin 1.0.
Armengaud and Lemale (B)	Air 75, paraffin injection 100	About 1040° entering nozzle	Above atmosphere	755	Air, water, paraffin	About 2.75 lb. of paraffin. steam consumption was high	300–400	5.2 neglecting compressor; (?) including compressor	Rateau 3-cylinder.	75	Paraffin pre-heated.
Torpedo turbine	Air 120	—	20	—	Air, water, paraffin	23.5 9.0 1.3	120	About 10.8 neglecting supply of compressed air	Air bottle holding 62 lb. at 2000 lb. pressure	—	Consumption during 80 seconds' run was:—Air 62.0 lb., water 24.0 lb., paraffin 3.5 lb. H.P. with air only = 35.
Karavodine	Explosion pressure 5 lb.	—	—	—	Air, petrol	About 55 lb. of petrol	1.6	2.5	Nil	Nil	Charging of explosion chamber is effected automatically at negative pressure of about 2 lb. below atmosphere. Rate of explosions about 40 per second.
Holzwarth (A)	Explosion pressure 80 lb. (varied from 55–120 lb. on trials)	Gas introduced at 60° F. Temp. of explosion about 2100° F.	About 13.0 lb. abs.	1100°, but usually from 900°–1000°	Power gas, but oil has been used.	*Never stated*	545 maximum	24.7	Rotary compressor and exhauster 5000 r.p.m.	+ about 12 lb. gauge and − 1½ lb.	The published results of the Holzwarth trials do not admit of checking. See Table I., Appendix, Holzwarth's book, and Schule's paper.
Holzwarth (B)	Designed for 200 lb. explosion pressure	—	—	—	Heavy oil	—	—	—	Rotary compressor and exhauster 5000 r.p.m.	—	No data available.
Rateau	Engine at ground level exhausts at about 40 lb.	Varies from 1200° to 1350° at ground level.	Above atmosphere	Varies with altitude. About 1100° on ground	Exhaust gas from petrol engine using 0.5 lb. per B.H.P.	About 3.0 lb. of petrol, or six times fuel of engine per H.P. of turbine	For 300 H.P. Breguet engine, turbine gives about 50 H.P.	Turbine $\eta = +50.0$ Fan $\eta = \pm 50.0$ Overall $\eta = \pm 25.0$	No compressor for turbine	—	The record altitudes for aeroplanes have only been obtained with this supercharging device.

The Completion of the Rhaetian Railway Electrification.

No. II.*

BETWEEN the years 1912 and 1914 fourteen electric locomotives were put into service on the Engadine lines of the Rhaetian system. The first seven engines to be delivered were of the 1–B–1 (2–4–2) type, each with one motor having an hourly rating of 300 horse-power. The other seven were of the 1–D–1 (2–8–2) type, four of which were equipped with two motors each of 300 horse-power rating, while the remaining three were of similar design but with two 400 horse-power motors. A further locomotive of this latter type was put into service in 1918.

As the process of electrification was extended, it became necessary to consider a still more powerful type of locomotive for use on the long and steep gradients which are encountered on certain portions of the system. On the Albula section, in particular, the conditions are specially severe as, for a distance of about 21 kiloms., the gradient is 1 in 28.6, and the speed of the train must be maintained at 30 kiloms. per hour, with a total train weight of 200 tons. In order to meet the requirements locomotives with an hourly rating of 1200 horse-power were designed. These locomotives were of the C–C (6–0–6) type, and six were put into service in 1921 and four in 1922.

THE C–C TYPE LOCOMOTIVES (1921).

The electrical equipment of these locomotives was supplied jointly by Messrs. Brown, Boveri and Co., and the Ateliers de Construction Oerlikon, while the mechanical part was built by the Swiss Locomotive Works of Winterthur. This is of particular interest as, we believe, it is the first occasion on which an electric locomotive combining the experience and practice of these three large firms has been built.

The locomotives are designed for hauling, at a speed of 30 kiloms. per hour, a total load of 150 tons on the maximum gradient of 1 in 22.2 and 200 tons on inclines of 1 in 28.6; they are further capable of negotiating curves with a minimum radius of 100 m. on open track and of 80 m. on points. The main particulars of the engines are set out in the table given on the next page.

The illustration we reproduce in Fig. 13 shows the type and design. The weight of rail used is 23.5 kilos. to 27 kilos. per metre, or about 46 lb. to 54 lb. per yard, and the permissible load per locomotive axle 11 tons.

The Mechanical Construction.—The side frames of the bogies are arranged outside the wheels, so as to increase the width of the bogies and permit of the use of motors of the same size as those used for standard gauge locomotives; the front and rear axles are in rigid bearings, while the middle axle has a certain amount of lateral play. The locomotive is provided with two motors, which are mounted on the underframe and arranged one over either bogie. The torque of motor is transmitted by means of double helical gears to a jack shaft and thence to the driving wheels, as shown in the illustration Fig. 13. The bogies are not coupled together, so that each centre pin has to transmit half the total tractive effort.

The locomotive is equipped with the Hardy vacuum brake system, arranged for use throughout the train. Each of the six wheels of the two bogies are provided with brake blocks, and the total force exerted on the wheels amounts to about 60 per cent. of the total

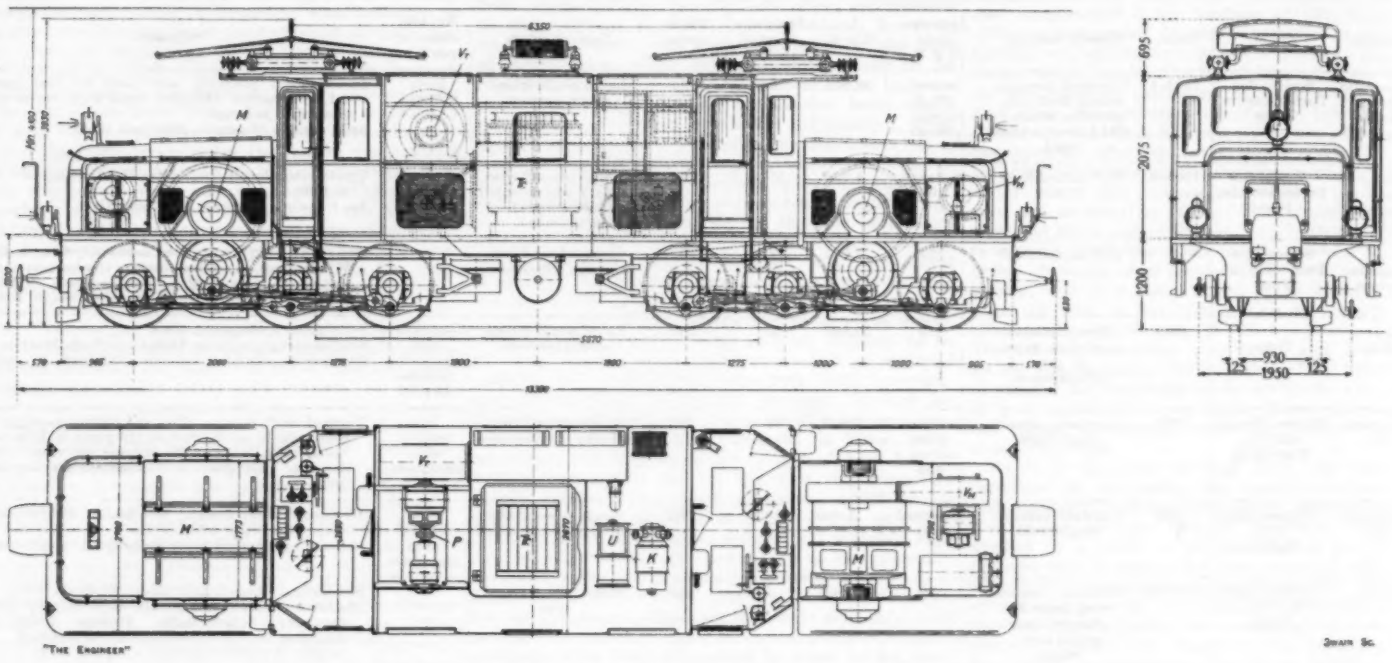


FIG. 13—1200-H.P. C-C TYPE SINGLE-PHASE ELECTRIC LOCOMOTIVE

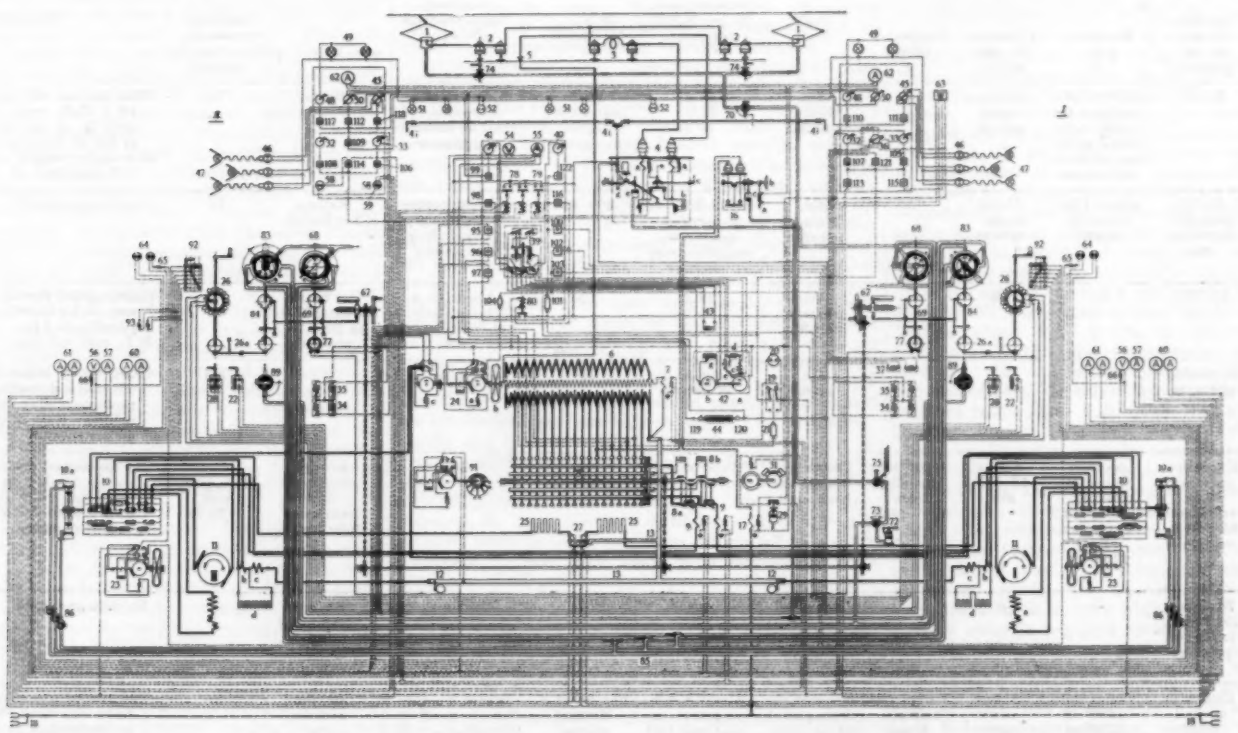


FIG. 14—ELECTRIC CONNECTIONS FOR 1200-H.P. C-C TYPE ELECTRIC LOCOMOTIVE

adhesive weight. Under normal conditions the vacuum brake is, however, not utilised for the locomotive itself, but only for the rest of the train. This prevents undue heating of the tires of the driving wheels and reduces the chance of metallic dust from the brakes penetrating into the electrical equipment. Combined with the mechanism of the vacuum brake on the locomotive, there is a hand brake which permits of the application of a braking pressure to the wheels

* No. I. appeared May 4th.

equal to about 50 per cent. of the adhesive weight.

The Electrical Equipment.—The current is collected from the overhead line by two pantographs, and is then led through a choking coil to a transformer where the line pressure is stepped down from 11,000 volts to that necessary for the traction motors, eighteen tappings being provided, the highest voltage available being 610.

The pantographs are operated pneumatically in conjunction with the main isolating switches. The high-tension switch, which is of the oil-break type and is arranged in the roof of the locomotive, is closed pneumatically and released electrically by means of contact mechanism provided on the control valve. A mechanical release is also provided which may be used in case of emergency. The high-tension switch is further fitted with three maximum current relays, one in the transformer circuit and the others in the circuits of the two motors respectively. The drawing given in Fig. 14 shows the arrangement of the electrical and pneumatic connections on the locomotive.

Particulars of C-C Type Locomotives (1921).

Gauge	1 m.
Maximum speed	45 m.p.h.
Traction system	Single-phase
Line pressure—	
Maximum	11,500 volts
Minimum	8500 volts
Frequency	15 to 16 cycles
Height of overhead conductor above rail—	
Minimum	4100 mm.
Maximum	6400 mm.
Maximum height of the bow above rail—	
With lowered pantograph	3970 mm.
With raised pantograph	6450 mm.
Maximum length of bow	1340 mm.
Total length over buffers	13,300 mm.
Maximum width of locomotive	2700 mm.
Diameter of driving wheels	1070 mm.
Weight of mechanical part, including brakes, but excluding snow plough	37,950 kilos.
Weight of electrical equipment	27,750 kilos.
Total weight, including *personnel* and sand, but excluding snow plough	66,150 kilos.
Weight per metre run, maximum	5.7 tons

The transformers Tr—Fig. 13—each have a continuous rating of 940 kilovolt-ampères, and are of the air-cooled type. The cooling air is supplied by a fan V_T driven by the motor P, and placed near the transformer. The low-tension winding is arranged under the high-tension winding. The controller is of the sliding contact type with eighteen positions for the eighteen tappings, and it is fitted with main and auxiliary contact fingers so arranged that a bridging coil is inserted in the circuit when passing from one step to the next. All interruption of current in the circuits of both the main and auxiliary contact fingers actually takes place in a breaker, which is provided with magnetic blow-outs. This breaker is arranged at one end of the controller. The controller is operated mechanically by means of a chain, while the reversing mechanism is mounted close to the motor and is operated pneumatically.

The two traction motors are series-wound twelve-pole machines, each having an hourly rating output of 600 horse-power, and a continuous rating of 500 horse-power at 615 revolutions per minute, corresponding to a train speed of 30 kiloms. per hour. They are fitted with commutating poles with both compensating and shunt windings, and are provided with special resistances between the commutator and the armature winding. The motors M are of the totally enclosed end shield type, with forced ventilation, the cooling air being supplied by a motor-driven fan V_M mounted close to the machine. The total weight of each motor without its fan or gears is 5750 kilos., or nearly 5½ tons.

The locomotives are arranged for electrical braking with resistances. When using this mode of braking the field windings are connected in series by the reversing switches, the excitation current being supplied by an exciter, and the machines then operating as separately excited direct-current generators. The voltage of the exciter is regulated by means of a shunt rheostat, so that the braking effect can be varied very gradually. The braking resistances are mounted close to the transformer and are cooled by means of the current of air escaping from it. The electric braking system is so arranged that it is used in conjunction with the vacuum brake.

The auxiliary plant, such as the fans V_T and V_M, the compressor K and the locomotive lighting set U, are operated at a pressure of 220 volts. The lighting set generates direct-current at 18–25 volts, and works in parallel with a 60 ampère-hour battery of accumulators, which also serve for the excitation of the exciter used for electric braking.

Regenerative Braking on the 1–D–1 Locomotives (1914).—Up to the year 1918, neither resistance nor regenerative braking was provided on the locomotives. When, however, the section Klosters-Davos, with its steep gradients of 1 in 22.2 was electrified, it was realised that considerable energy might be recovered by the use of regenerative braking, and, consequently, the three 1–D–1 locomotives (1914) which, by reason of space and weight conditions lent themselves better for the purpose, were adapted for regenerative braking by the Behn-Eschenberg method. The necessary equipments were supplied by the Ateliers de Construction Oerlikon. They were designed for dealing with a load of 95 to 80 tons on gradients of 1 in 22.2, corresponding to 100 tons on inclines of 1 in 28.6 at a train speed of 30 kiloms. per hour, the vacuum brake being used for the remaining part of the load. The method of connection is shown diagramatically in Fig. 16. When using regenerative braking the field windings of the two motors are connected in series by means of he reversing switches, and the machines then work as separately excited generators, the excitation current being supplied by the main transformer; furthermore, choking coils are provided for limiting the armature current. The braking effect is regulated by the sliding contact controller of the locomotive, which connects the armature and field winding of the machines to the various tappings of the transformer. The induotve shunts, which are connected across the commutating poles of the motors serve for improving the commutation, when braking. The total additional weight of the regenerative braking equipment amounts to 2390 kilos., or a little over 2½ tons. The results obtained so far with this method of braking have proved entirely satisfactory.

In order to determine the relation existing between the energy absorbed when travelling on up-gradients and that regenerated on down-gradients, a trial run between Landquart and Davos and back, was carried out on the night between January 11th and 12th, 1922. The time was so chosen that no other trains were on the sections fed by the generating station in question during the trial period. The readings

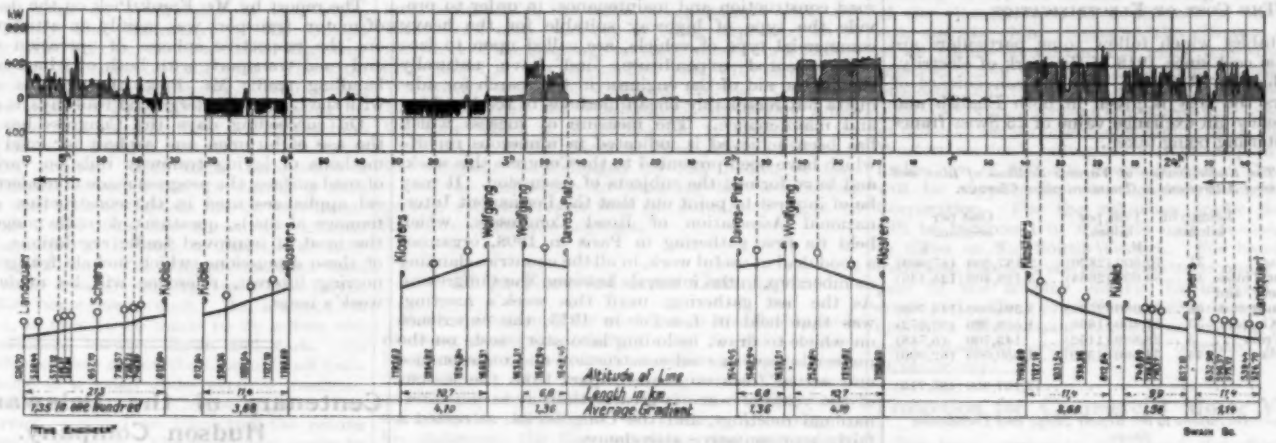


FIG. 15—WATTMETER RECORD OF TRIAL TRIPS AND GRADIENTS OF LINE

taken on the locomotive and on the high-tension side of the transformer are given in the following table:—

Up gradient	1 in 28.6	1 in 22.2	—	—
Down gradient	—	—	1 in 22.2	1 in 28.6
Speed, kiloms. per hour	38	28.5	29	36
Pressure, volts	11,000	11,000	10,910	10,050
Current, amp'res	48	49.2	45.6	31.6
Energy absorbed (+) or regenerated (−), kilowatts	+ 490	+ 472	− 145	− 145
Calculated power factor	0.93	0.872	0.292	0.415
Frequency	17	17	17	17

It will be seen that, on gradients of 1 in 22.2 and 1 in 28.6, approximately 30 per cent. of the energy was recuperated during down-grade operation; at the same time it must also be borne in mind that about 42 kilowatts was absorbed by the auxiliaries on the locomotive.

The recording wattmeter strip, which was taken at the generating station, is reproduced in Fig. 15. In this diagram the shaded areas represent the power absorbed, while the blackened areas correspond to the regenerated energy. In this connection it may be mentioned that, owing to a defect in the control apparatus, the regenerative braking could not be used between Wolfgang and Davos-Platz—a distance of about 3 kiloms. with a gradient of 1 in 40.

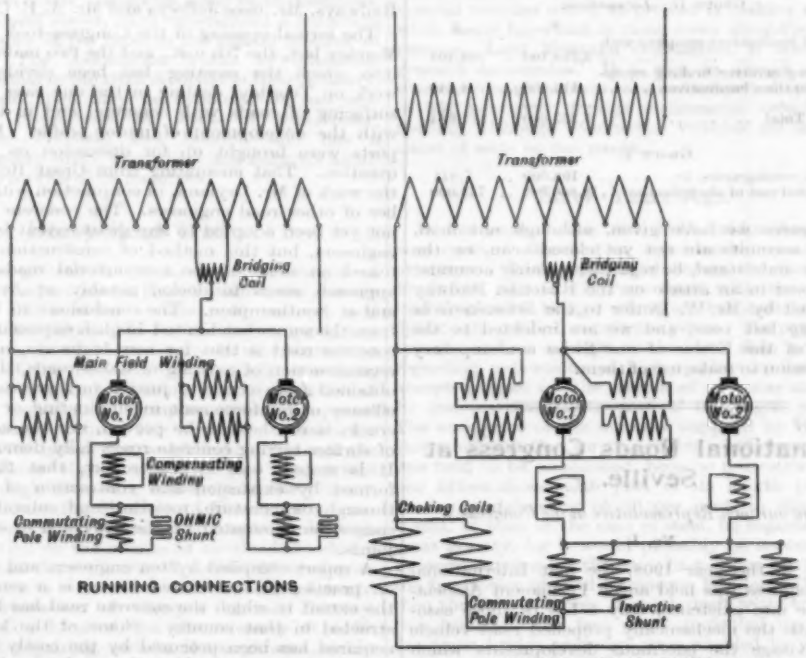


FIG. 16—ELECTRICAL CONNECTIONS FOR RUNNING AND BRAKING

Had it been used over this section about an additional 10 kilowatt-hours would have been recovered.

Train Heating.—Electric heating is used throughout the trains. The heaters are, at present, connected directly across the 300 volts heating circuit; when, however, the pressure of the heating supply is raised to 1200 volts, as it is to be, they will be arranged four in series. The power allowed for heating the compartments was originally 190 to 250 watts per cubic metre. This was, however, found to be insufficient, and a rating of 300 to 400 watts per cubic metre was subsequently adopted. The heating of the corridors of the coaches is, however, based upon a rating of 150 watts per cubic metre.

The Cost of Electrification.

In the tables which follow some particulars are given of the cost since 1918 of the work of electrifying the Rhaetian Railway. For the convenience of our readers the cost is given in both English and Swiss currency, an exchange value of 25 Swiss francs to the £1 sterling being taken.

Group A.—*The Electrification of Various Sections of Line and Making Alterations to Communication Circuits.*

Section.	Length in kilom.	Cost per kilom. F.	Cost per kilom. £	Cost per section. F.	Cost per section. £
Bevers-Filisur	31	70,500	(2820)	2,187,500	(87,500)
Davos-Filisur-Thusis	45	69,600	(2664)	3,128,400	(125,136)
Davos-Klosters and Thusis-Landquart	56	64,000	(2560)	3,594,000	(143,760)
Landquart-Klosters	33	47,400	(1896)	1,564,300	(62,572)
Reichenau-Trins	5	28,800	(1152)	143,700	(5,748)
Trins-Disentis	45	34,500	(1380)	1,550,000	(62,000)
Total				12,167,900	(486,716)

Group B.—*Alterations to the Repair Shops and Locomotive Sheds.*

	F.	£
Extending the locomotive erection sheds	200,000	8,000
Heating installations for the Landquart locomotive sheds	103,000	4,120
Heating installation for the Samaden locomotive sheds	59,000	2,360
Lengthening the passenger platform and equipping the winding shed and the main workshops at Landquart	183,000	7,320
Equipping the Samaden locomotive sheds	45,000	1,800
Total	590,000	23,600

Group C.—*Heating of Coaches.*

	F.	£
Cost of providing 113 passenger coaches and goods wagons with electric heating equipment	282,500	11,300
Increasing the electric heating equipment in 75 passenger coaches	150,000	6,000
Cost of providing heating cables on 124 goods wagons	86,800	3,472
Total	519,300	20,772

Group D.—*Locomotives.*

	F.	£
Cost of 11 locomotives complete with spares	5,210,100	208,404
Cost of regenerative braking equipment for three locomotives	113,500	4,540
Total	5,323,600	212,944

Group E.

	F.	£
Sundries, contingencies, &c.	198,600	7,944
Total cost of electrification	18,800,000	752,000

The figures we have given, although not final,—for all accounts are not yet closed—can, on the whole, we understand, be regarded as fairly accurate. They appear in an article on the Rhaetian Railway contributed by Mr. W. Dürler to the *Schweizerische Bauzeitung* last year, and we are indebted to the courtesy of the Editor of our Swiss contemporary for permission to make use of them.

International Roads Congress at Seville.

(*From our own Representative at the Congress.*)

No. I.

When, in the year 1908, the first International Roads Congress was held and a Permanent Association came into existence, only a few of those associated with the mechanically propelled road vehicle could envisage the enormous developments which have since taken place. The experience of the years of war was required to show the real function of the road motor in the transport systems for the supply of armies in the field, if not for normal needs in time of peace. The movements of men and munitions, especially in the war areas, were beyond the capacity of the railways, and recourse was had to the roads. A network of 4000 miles of roadway behind the English lines was kept in constant repair. Over 450,000 road vehicles had been sent from Great Britain into France up to the Armistice, while it is estimated that from 180,000 to 200,000 motor vehicles were in use at one time for the support of the Allied armies on the Western Front, and that they, together, carried up to as much 10,000,000 ton-miles in a day. That was a period of fierce test, through which the commercial motor passed, approved and accepted, and the consequences of which cannot be lost. Motor road transport was established as securely as railway transport.

If all the progress anticipated by those associated with the mechanically propelled road vehicle has not been achieved, a remarkable advance has, notwithstanding some obvious handicaps, been recorded. The problems which await solution are partly technical and partly financial. The Roads Congress, in its programme for the Seville gatherings, has covered both aspects of the question, but has naturally concentrated attention on the road rather than the vehicle using it. It is common knowledge that from various causes the advance in highway construction has failed to keep pace with the growth of motor traffic on roads. Those responsible for road construction and maintenance, in order to provide the type of highway suitable for the heavy commercial type of vehicle, are called upon to face unprecedented expenditure, and have naturally sought the aid of the engineer in the search for adequate but reasonably cheap methods of road making and maintenance. The measure of success which has been achieved is indicated in numerous reports which have been presented to the Congress this week, and have formed the subjects of discussion. It may be of interest to point out that the Permanent International Association of Road Congresses, which held its first gathering in Paris in 1908, organises a good deal of useful work, in all the countries claiming membership, in the intervals between the Congresses. As the last gathering, until this week's meeting, was that held in London in 1913, the experience on which to draw, including laboratory tests on the materials used in road construction and maintenance and actual tests on roads—apart from the lessons of the years of war—is greater than at earlier international meetings, and the Congress has attracted a fairly representative attendance.

The Governments which accepted invitations to be represented at Seville include those of Great Britain, the United States, Canada, France, Belgium, Italy, Switzerland, the Netherlands, Sweden, Bulgaria, Roumania, Czecho-Slovakia, Japan, Mexico and South America.

As the membership of the Association includes, in addition to delegates of Governments, those representing public departments, municipalities, chambers of commerce, technical and scientific institutions, and a wide range of purely commercial interests, the Congress assumes a wide basis. Among those from Great Britain who figure in the list of delegates are Sir Henry Maybury, representing the Roads Department; Mr. C. H. Bressey, Chief Engineer of that Department; Mr. J. S. Killick, Mr. John Brodie, Mr. A. Dryland, Mr. Arthur Collins and Mr. A. E. Brookes. These stand, of course, for the technical side of road construction and upkeep. The names on the traffic side include those of Mr. E. S. Shrapnell Smith, Mr. F. Pick, of the London Underground Railways, Mr. Rees Jeffreys and Mr. A. E. Cave.

The formal opening of the Congress took place on Monday last, the 7th inst., and the two main sections into which the meeting has been divided began work on Tuesday, dealing in the one case with the surfacing of roads with concrete, and in the other with the development of motor traffic. Eight reports were brought up for discussion on the first question. That emanating from Great Britain was the work of Mr. Dryland, in conjunction with a number of other road engineers. The concrete road has not yet been adopted to any great extent by British engineers, but this method of construction is being tested on some of the new arterial roads and on approach roads to docks, notably at Avonmouth and at Southampton. The conclusions to be drawn from the somewhat limited English experience of the concrete road is that for new highways, or for the reconstruction of existing unstable roads, the results obtained from concrete justify further trials. The efficacy of reinforcement in eliminating or reducing cracks is not held to be proved, nor the advantage of surface tarring concrete roads fully demonstrated. It is stated, too, in this report, that the cracks formed by expansion and contraction of concrete through temperature, moisture and subsoil changes cannot be eliminated by the provision of expansion joints.

A report compiled by ten engineers and scientists on practice in the United States is a reminder of the extent to which the concrete road has been constructed in that country. Some of the knowledge acquired has been procured by the costly trial and error method—much of it is the result of well-directed experiments, and much to the outcome of patient research work. A great deal of useful information has been embodied in the report in the hope that it may be useful to engineers in other countries where the concrete road has not yet been adopted to any extent. It was stated that the first cement road was laid in the early nineties and that, after having been subjected to heavy traffic for twenty-eight years with but small charges for maintenance, is still in fair condition to-day. There are now over 62,000,000 square yards of concrete road in the United States, and the fundamental principles of successful concrete pavements are held to be well established. In connection with reinforcement, the hope is expressed that in spite of the divergent ideas which are still in evidence, a rational basis for designing and placing reinforcement on roads will soon be evolved. At the present time reinforcement takes two forms—circumferential and corner reinforcement and reinforcement over the entire area of the pavement. The whole question is, however, an economic one. A satisfactory pavement can, it is asserted, be obtained by the use of plain concrete, and it is for the engineer to determine whether this method or the use of reinforcement is to be preferred.

On the Continent experimental work has been done with special systems like Soliditit and Rhoubenite—the last named a form of pulverised sawdust, with which is incorporated a special tarry mixture, which is used in conjunction with a rich mortar concrete. Experience with these systems is stated to have been satisfactory.

The report by Mr. Frank Pick on the development of motor transport was mainly an attempt to mark out the respective spheres of operation of railway and road transport, with both of which methods of handling traffic Mr. Pick, through his connection with the London Underground Railways, is associated.

On succeeding days the Congress has discussed the use of bitumen and asphalt for road surfacing, methods of laying tramway rails on various kinds of road surface, the progress made in modern mechanical appliances used in the construction and maintenance of roads, questions of traffic congestion and the need of improved traffic regulations. To some of these discussions, which include features of engineering interest, reference will be made in next week's issue.

Centenary of the Delaware and Hudson Company.

We in this country are so much in the habit of looking upon America, especially in the domain of engineering, as a new country, that it comes to us somewhat as a shock to learn that the centenary habit, as we may call it, has already been formed in the United States.

Monday, April 23rd, was the one hundredth anniversary of the granting of the charter of the Delaware and Hudson Company, which is consequently distinguished as being the oldest transport Corporation in the Western Hemisphere. The company was formed for the purpose of bringing to market in New York the anthracite coal of Pennsylvania, then but little appreciated because of the difficulty of burning it. To transport the coal, inclined planes over the Moosic Mountains, from Carbondale to Honesdale, were employed, joined by a canal from the latter place to Rondout on the Hudson River.

From the first the intention was to use locomotives, and in 1826 the Pennsylvania Legislature authorised the company to construct a railway. Following upon this the managers sent Horatio Allen as their representative to England in 1828. He ordered an engine known as the Americn from Robert Stephenson and Co., of Newcastle, and three others, known as the Stourbridge Lion, the Delaware and the Hudson respectively, from Foster, Rastrick and Co., of Stourbridge. These engines arrived in New York in the order named, but the Stourbridge Lion was the first to be tested. This interesting event took place on August 8th, 1829, at Honesdale, hence, this locomotive was the first actually to run over a track in the Western Hemisphere. Unfortunately, it was much heavier than Mr. J. B. Jarvis, the Chief Engineer, had anticipated, and was considered too heavy for the track, which was of the strap rail construction supported on wooden trestles where it crossed the Lackawaxen Creek. Consequently, none of the engines were ever put into regular service.

The history of the company is a long and interesting one, but it is unnecessary to enter into it, as we understand it is the intention to print a souvenir book giving this history in detail. It may be mentioned, however, that the canal was abandoned twenty-three years ago, and that the mining properties have been greatly developed, so that the company now raises the second largest tonnage of anthracite of any corporation in Pennsylvania.

The centenary celebration took the form of a banquet at the Hotel Astor, New York, at which upwards of six hundred guests, representing leading transport, banking and industrial interests of the United States, were entertained.

The President of the Delaware and Hudson Company, Mr. L. F. Loree, an outstanding personality in American railroading, in his after-dinner speech, condemned Federal interference in railroad management and gave it as his opinion that "Railroading is no longer a business; it has become a calamity." Mr. J. S. Alexander, of the National Bank of Commerce, spoke on "Banking and Transportation," and Mr. H. W. Dickinson, of the Science Museum, South Kensington, gave a scholarly address on the history of the use of steam power. After the banquet a special train of sleeping cars took a number of guests from the Pennsylvania Station to Scranton, Pa. After breakfast had been served a visit was paid to an experimental coal-dressing plant on the flotation principle, using sand as the agent, the results of which are promising. A new coal-breaking, jigging and tailings plant was also inspected.

The veteran employees of the company and the guests were entertained to luncheon at the Hotel Casey, Scranton, where the President, Mr. L. F. Loree, spoke on "The Century's Association of Management: Capital and Labour"; Mr. W. H. Williams, Vice-president, spoke on "Anthracite Development and Railway Progress," and Mr. Dickinson spoke on "The Early Days of Canals, Railways and Locomotives."

After luncheon the old track from Carboudale to Honesdale and the bed of the canal onwards were viewed from the train of special cars. The party arrived in New York late in the evening.

A Seven-Day Journal.

Two Record Flights.

Two record aeroplane flights have been made since we last wrote, both of which have been hailed with much applause, although neither, by comparison with earlier performances, seems to us to indicate much, if any, advance. Starting from the neighbourhood of New York on Wednesday of last week, Lieutenants Kelly and Macready, of the United States Army Air Service, flew without alighting to San Diego, on the coast of California. The total distance covered was approximately 2700 miles, and the time occupied 26 h. 50 min., indicating an average speed of 100 miles an hour. The machine used was a Fokker monoplane, driven by a 400 horse-power Liberty engine. This flight establishes a record for distance covered, but for daring it does not compare with that of Captain Alcock and Lieut. Brown, who, in June, 1919, flew across the Atlantic from Newfoundland to Ireland, a distance of 1880 miles, in 16 h. 12 min. The Vickers machine used on that occasion was driven by two Rolls-Royce engines of 350 horse-power each. An attempt, it is understood, is now to be made to fly across the American continent between dawn and dark. On Sunday, M. Barbot flew across the Channel and back again to France in a small glider type of machine, fitted with a 15 horse-power Clerget engine. The outward journey occupied an hour and the return three quarters of an hour. The flight was made in connection with a competition for a prize offered by a French journal for a double trip across the Channel on an aeroplane having a motor with a cylinder capacity not exceeding 1500 cubic centimetres. In order that this feat may be viewed in the right perspective, we may recall that M. Blériot's historic flight of July 25th, 1909, was carried out in 33 min. on a biplane equipped with a motor of 24 horse-power.

Stainless Steel American Patents.

Elsewhere in this issue we reprint the judgment of the United States Circuit Court of Appeals in the appeal of the American Stainless Steel Company against the previous decree of the District Court under which the Ludlum Steel Company was absolved from the charge of infringing the Haynes and Brearley patents for stainless steel. The judgment of the Court of Appeals, as recorded in last week's Journal, reversed the earlier decree and declared the Ludlum Company to have infringed both patents. That company, we learn, has now applied for a re-hearing of the appeal, but its request in this matter has been refused by the Court.

Sir Guilford Molesworth.

On Thursday of last week Sir Guilford Lindsey Molesworth entered his 95th year, having been born on May 3rd, 1828. Although his advancing years have impaired his eyesight, he still retains all his faculties, and has a remarkably well-preserved memory. His engineering education was begun at the College of Civil Engineers, Putney, and was continued during his apprenticeship under Sir William Fairbairn. For a time he was engaged on the London and North-Western and the London and Brighton Railways, and during the Crimean War he served in Woolwich Arsenal. From 1859 to 1871 he was intimately associated with the Ceylon Government Railways, and from the latter date until 1889 he occupied the post of Consulting Engineer for State Railways to the Government of India. His well-known pocket-book of engineering formulæ, first published in 1863, is but one of his numerous contributions to literature, his other writings covering a wide field, embracing novels, a text-book of bimetallism, treatises on socialism, political economy, masonry dams, light railways and reason and instinct in ants, and a life of his father, the late Vicar of Rochdale.

The Shipyard Dispute.

On Friday of last week it was intimated that the Joiners' and Plumbers' Unions had agreed to accept the overtime and night-shift agreement signed on March 22nd by the Federated Engineering and Shipbuilding Trades on behalf of all the constituent bodies of that organisation. The members of these two unions had remained at work "under protest," and were due to be locked out by the employers on Monday of this week. In consequence of their decision to accept the agreement the federated employers withdrew the notices against them, with the result that no actual stoppage has occurred. The Boilermakers' Union, on the other hand, persisted in its attitude of keeping its members away from work while a ballot was being taken among them. That ballot was completed on Monday, but so far the result has not been officially declared, although it is understood that it showed a small majority against acceptance of the agreement. The position thus created in the shipyards is a most unfortunate one, for the stoppage of work by the boilermakers for any length of time will automatically result in others being thrown out of work. In the Newcastle district—and, presumably, the same circumstances affect the Birkenhead area—anxiety is being expressed as to the effect of the stoppage on the contract for a battleship placed at the end of last year with Armstrong Whitworth and the Wallsend Slipway Company. It is said that the Washington Agreement limits the time which it is permissible to spend on the construction of the vessel to three years, and that if the stoppage is prolonged for any length of time it will be impossible to complete her within this period, with the result that the Admiralty might be forced to cancel the contract.

Ships Received from Germany.

Some indication of the work lost to British shipyards resulting from the handing over to this country by Germany of mercantile vessels under the terms of the Treaty of Versailles, was given in Parliament on Monday by Viscount Wolmer, Parliamentary Secretary to the Board of Trade. According to his statement the Germans have now surrendered to us 427 vessels of 1,890,896 gross tonnage. Of these vessels four, having a total of 21,873 gross tons, were lost before being sold. The others were sold for £20,248,531. It thus appears that the average size of vessel handed over was about 4430 gross tons, and that the price obtained averaged about £10 16s. per gross ton.

Industrial Accidents.

According to a statement made by Lieut.-Colonel Pickard, the general secretary of the British Industrial "Safety First" Association, the sum expended in this country by way of compensation following accidents to workers, amounts to about £5,000,000 yearly. In addition, there are legal, medical and other expenses, which are estimated to increase this figure by some 50 per cent. The Association now numbers about two hundred large firms, representative of practically every industry. By the adoption of its "Safety first" methods some of its members, Colonel Pickard states, have experienced a reduction of as much as 76 per cent. in the annual number of accidents. The Association works by educating those concerned in the risks involved in their industry, and how best they may be avoided. It has now four local committees at work—in Manchester, Birmingham, Sheffield and London—and has a staff of "Safety first" specialists and lecturers available for the service of its members.

Heavy Road Traffic.

With the growth in the amount and weight of mechanical road transport, the question of the damage caused by the vehicles to the road surfaces and who should be responsible for making it good, was bound to arise in an acute form. In this connection the action of the Eccles Town Council, in seeking to provide a weighing machine for the detection of overloaded vehicles, is symptomatic. It appears that the County Council has declined to assist the Corporation to install the weighbridge, although the proposal affects almost entirely main road traffic passing through the town, while, up to the present, efforts to induce the Ministry of Transport to contribute to the cost have received no response, although the fines levied on the owners of overloaded vehicles all go to that department. A somewhat analogous case has arisen in connection with the action brought by the Corporation of Glasgow against Barclay, Curle and Co., Limited, for the recovery of £460, the cost of repairing certain thoroughfares in the neighbourhood of the firm's works, consequent upon the damage caused thereto by the company's heavy boiler traffic over the streets in question. Following judgments in the Courts the Corporation has now taken the case to the House of Lords. It is understood that claims for a similar nature against a considerable number of other large engineering firms in Glasgow are dependent upon the ultimate decision in the present action.

The South-Eastern Electrification.

The first step beyond the planning stage has now been taken in connection with the electrification of the suburban lines of the South-Eastern and Chatham section of the Southern Railway. An order, we learn, has just been placed with the Cargo Fleet Iron Company for 7000 tons of conductor rails, while Messrs. Doulton and Messrs. Buller have been awarded contracts for the insulators for the rails. It may be recalled that the electrification work will be conducted in three stages, the first involving the transformation to electric traction of the suburban lines lying within a radius of fifteen miles from Charing Cross, the second covering the extension of the electrification to a distance of thirty miles out, and the third aiming at the ultimate handling of all trains—suburban and main line—by electric traction within the thirty mile zone. It was at first proposed that the energy should be supplied on the 3000–1500-volt direct-current three-wire system, but in order to secure interchangeability with the South-Western section's rolling stock the final plan adopted makes use of 600-volt direct current. The current will be supplied by the London Electric Supply Corporation. For the suburban traffic the trains will be composed of multiple unit coaches, similar to those on the South-Western. For handling the main line trains in the electrified zone under the final part of the scheme electric locomotives will be employed. Thus when the full scheme is in complete operation all the trains entering or leaving the company's London termini will be operated by means of electricity.

Protection for Commercial Motor Vehicles.

We have previously mentioned the efforts being made to secure protection from foreign competition for commercial motor vehicles by the imposition of an import tax, such as is applied in the case of private motor cars brought into the country from abroad. So far, apparently, the Government has made no response to the requests of the manufacturers, although it is maintained that by complying therewith it would materially assist in the relief of unemployment and secure economy in the administration of the Customs which at present is entailed in considerable unnecessary expenditure by the difference of treatment accorded to commercial and private vehicles. In a letter to the editor of *The Times*, Lord Montagu of Beaulieu has called attention to the fact that the advantage is so much with the foreign firms that they are in some instances actually short of hands, and that at least one—the Renault Works, at Billancourt, France—has found it necessary to advertise in this country for fitters, electricians, machine hands, polishers and other workpeople. On the other hand, there is hardly one British firm producing commercial vehicles which at present is making a profit, while many have had to close down altogether. The position, Lord Montagu emphasises, is one of the greatest seriousness. It is also an absurd one, for whereas foreign private cars are subjected to a duty of 33⅓ per cent., foreign commercial vehicles pay nothing, although commercial vehicles are the chief cause of wear on our roads.

Sixty Years Ago.

In our issue of May 8th, 1863, bridge design and construction absorbed a considerable amount of attention. In a paper read before the Society of Engineers, Mr. G. G. Page dealt with the Chelsea iron suspension bridge, which at that date had been open to the public for some five years. The paper contained a curious sidelight on the ideas then prevalent regarding indications of high quality in iron. An accepted figure for the stretch of iron was stated to be one ten-thousandth part of its length per ton. The excellence of the material supplied by Howard, Ravenhill and Co., for the chains of Chelsea Bridge was held to be established, because it stretched only one fifteen-thousandth part of its length per ton. To-day a deficiency of 50 per cent. in elongation would, at least in the case of steel, be regarded with great gravity, for it would probably be accompanied by excessiveness brittleness. In a paper read before the Institution of Civil Engineers, Mr. Zerah Colburn, then the Editor of this journal, dealt with American iron bridges. The fact was commented upon that American bridge engineers were enabled to work to higher stresses than those used in this country, because of the superiority of their wrought iron resulting from the purity of the ore and fuel employed in its manufacture. In a short paragraph we recorded the laying of the foundation stone of the Blackfriars railway bridge. Complaint was made that this bridge was being pushed on to completion, while the new road bridge to replace "the present most dilapidated and unsafe pile of arches that now does duty at Blackfriars" was being held up, although its construction was in the hands of the same engineer—Mr. Cubitt. In another paragraph it was reported that two railway timber bridges, one at Walworth on the Chatham and Dover line and the other at Ely on the Great Eastern, had that week been set on fire and, in the second-named instance, destroyed. It was suggested that all wooden structures on railways liable to be set on fire should be impregnated with Burnett's fluid.

A New Cotton Depôt at Bombay.

ON March 13th last the new cotton depôt which has been built at Mazagon by the Bombay Port Trust was formally opened by Sir George Lloyd, G.C.I.E., D.S.O., the Governor of Bombay. This important depôt, the construction of which was begun in August, 1920, has, with its accessories, cost 1,62,62,036 rupees, or, at the present rate of exchange, just over £1,100,000. In connection with the ceremony, an interesting little brochure was prepared, and for the copy of it, from which the following information has been culled, we are indebted to the courtesy of Mr. W. H. Neilson, M. Inst. C.E., M.I. Mech. E., the Chief Engineer of the Port Trust. Although no statement to that effect is made in the brochure, there is no doubt that all the works which we are about to describe were designed by Mr. Neilson, though the whole of the construction work throughout was under the immediate charge of Mr. Framji Ruttonji, Honorary Executive Officer, who is referred to as being "an old and valued officer of the Trust."

Bombay has been the site of cotton manufacture and export for many centuries, and its present volume of trade is enormous. In the year 1921–22 it imported 3,462,479 bales and re-exported 2,464,749 bales. In the early days the bales of raw material brought into the city were stored and dealt with on the "Old Cotton Green" that stretched in front of the present Town Hall. As long ago as 1844, however, the congestion caused within the fort walls by the coming and going of vast numbers of bales of cotton brought about the transference of the "Green" to the site it has since occupied in Colaba. That position was, when it was chosen, particularly convenient, because in those times, when there were no railways and roads were few, nearly all the cotton was brought in by sea, that from the Gujarat and Central India coming from Dholera, Broach and Surat, and that from the Southern Deccan and Malabar coming from Kumta and other ports. At Colaba it was easily landed and as easily loaded on to boats for transference to the ships that lay out in the harbour. Later, however, the construction of railways, only one of which ran to Colaba, the building of docks at a distance away, and the multiplication of mills in the centre and north of the Island, meant that cotton had often to be carted into Colaba and almost invariably had to be carted away, which not only added to the expense, but resulted in a serious congestion of traffic. The necessity for a change in the position of the storage yard became more and more apparent as time went on, and it is a matter for wonder that decisive steps in that direction were not taken long before they actually were. It was necessary, however, in order that the depôt might occupy the position it does, for the Port Trust first to carry out what is known as the Mazagon-Sewree Reclamation, and that was not completed until the year 1913. Then, of course, the war came and the question was put on one side and not again brought forward until 1919.

The body responsible for carrying out the work is, as has been said, the Bombay Port Trust, which was constituted in the year 1873, so that its jubilee coincides with the completion of the new cotton depôt. The condition of affairs in the neighbourhood of the new depôt when the Trust took over the management of the port is illustrated in Fig. 1, which shows the relative positions occupied by the Sewree, Frere Land, Tank Bunder and Mazagon estates as they existed in the year 1873. On it has been traced in dotted lines the boundary of the Sewree-Mazagon Reclamation, which embraces an area of 571 acres, while the boundary of the land coming within the jurisdiction of the Trust is shown hatched. In Fig. 2 is shown the reclamation as it now exists. In addition to its principal feature—the cotton depôt—an extensive grain depôt has been constructed, while large depôts are being formed, or are already partially in use for iron, manganese and coal, and provision is being made for the landing and storing of bricks, hay and firewood. Furthermore, store yards have been provided for the Great Indian Peninsular and the Bombay, Baroda and Central India railways, and for the Government Telegraph Department. In fact, the whole of the reclaimed area will within a very short time be utilised.

Fig. 3 illustrates the cotton depôt to a larger scale. There are in all 178 cotton godowns or storage sheds, arranged in twenty groups, the number of godowns per group varying from six to twelve. Each godown is 111ft. long, 40ft. wide inside and 30ft. high to the eaves. With the bales stacked eighteen high, each godown will hold 7500 bales, so that there is covered storage room for 1,335,000 bales. In addition, there are 201 jaithas, or raised plinths, without any covering, on which cotton will be stored during the fair season. With bales stacked on them eight high, the jaithas are capable of accommodating 627,264 bales. As will be observed, the jaithas are interspersed irregularly among the godowns. The latter are all equipped with Grinnell sprinklers, supplied by Mather and Platt, Limited, and there are fire alarms which are operated by the flow of water, and which consist of bells that sound continuously as long as the water is flowing. Numerous fire hydrants have been erected throughout the depôt, and fire brigade and salvage corps stations are to be erected. An initial head of water is given by means of an overhead tank erected on a steel trestle 60ft. high.

Running right alongside the cotton depôt and between it and the grain depôt is a railway which has been built by the Port Trust, and which extends southward to beyond the large Alexandra Dock—a distance of just over 3 miles. There is also a railway yard with stations and offices. In all, there are 6¼ miles of track within the yard, and designs have been got out for twenty-four goods sheds, each 250ft. long by 50ft. wide, and each affording space for standing 2000 bales of cotton at a time. Up to the present only sixteen of these sheds have been actually constructed. They are, as will be observed, arranged *en échelon*, so as to allow of separate sidings for each shed. The sheds have flat roofs, and on three of them offices and quarters have been erected. The whole of the construction of the buildings, including the foundation piles, ventilators, &c., is of reinforced

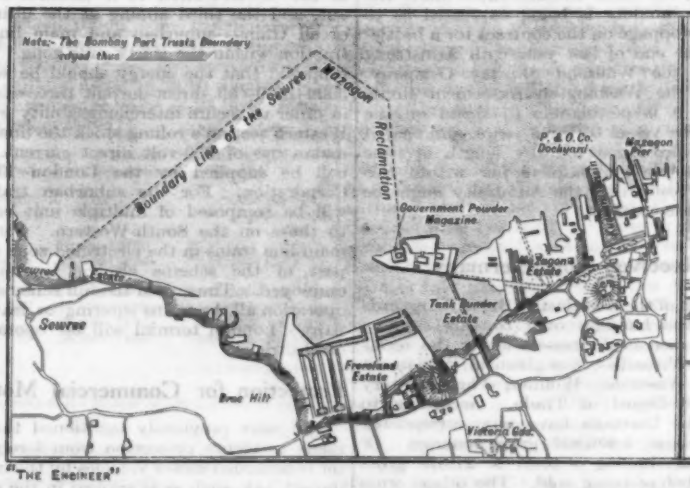


FIG. 1—THE NEIGHBOURHOOD OF THE NEW DEPOT AS IT WAS IN 1873

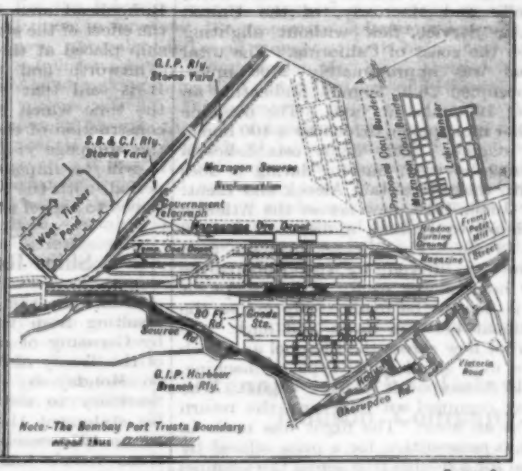


FIG. 2—THE RECLAMATION AS IT EXISTS

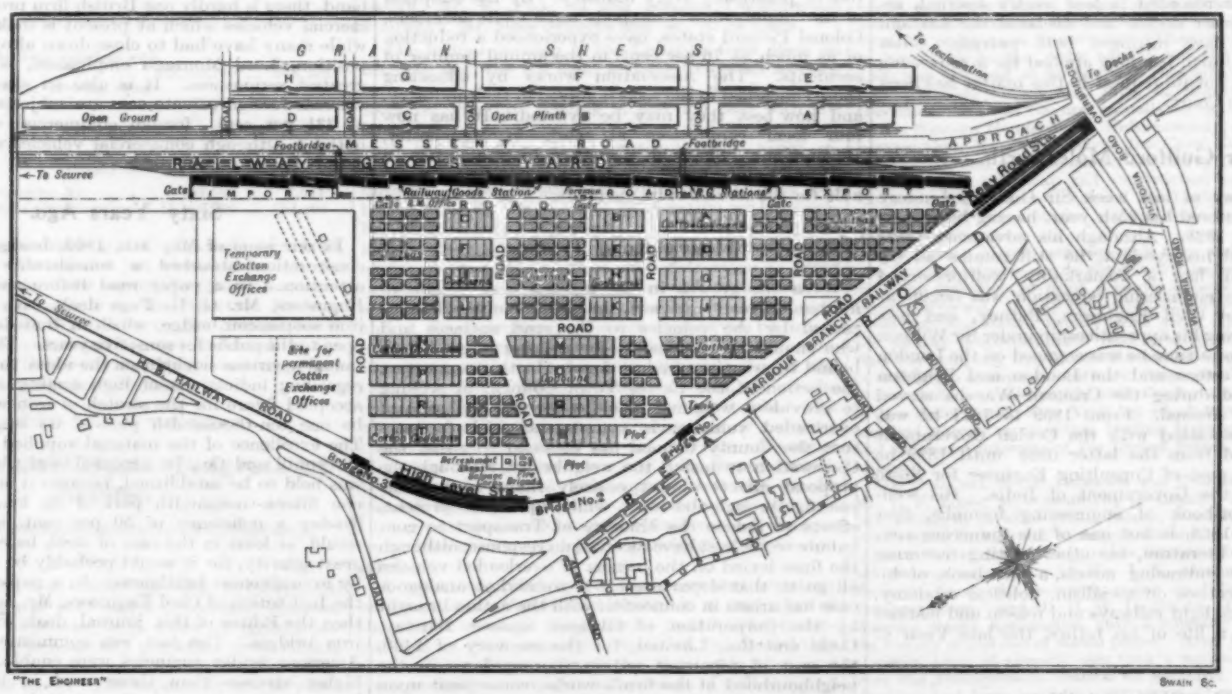


FIG. 3—THE NEW COTTON DEPOT AND GRAIN SHEDS

concrete. The roofs of the godowns are arched, and protected by a covering of Malthoid, supplied by McKenzies, Limited. Cross sections of a railway goods station, a cotton godown and of the High Level Station, which comes between Bridges Nos. 2 and 3, on the west side of the area occupied by the godowns are given in Fig. 5.

The Port Trust railway is in full working order, and will be the means of bringing cotton to the depôt and of carrying it to the docks. Passenger traffic will be provided for by the Harbour Branch of the G.I.P. Railway, which is being diverted, and which will, it is hoped, soon be completed into Victoria Terminus. On its electrification it will ensure rapid communication with the rest of the Island and with Salsette. The railway is already being worked to Reay-road Station, which is, as will be seen from Fig. 3, in close proximity to the cotton depôt. In order to prevent the railway, which is at present on the ground level, hampering access to the depôt from the west, that portion, including the special station for the depôt, which is referred to above as the High Level Station, is being raised on an embankment with three steel girder bridges over the main roads leading into the depôt.

Arrangements are being made for the extension of the tramway system along Reay-road, and for laying other connecting lines. Communication towards the north-west of the depôt is not, as yet, as full as is required, but the narrower portions of some of the roads are being widened, and when the roads projected by the municipality are completed, there will, it is said, be broad roads in every direction suitable for carrying cotton from the depôt to the mills throughout the Island. How numerous the mills are to the north-westward of the depôt may be gathered from Fig. 4. Large though the number of godowns provided—178—may appear, it is not surprising, in view of all these mills, that they have been over-applied for, and that the Trustees are already considering the immediate construction of additional storage accommodation. In this connection, it may be explained that at the present time there are in Bombay as many as eighty-six mills equipped with 300,000 spindles and 52,000 looms. It is calculated that 74 per cent. of the total quantity of yarn spun and 87 per cent. of the cloth woven in India are produced in the Bombay Presidency, and the overwhelming preponderance of these industries is concentrated in the Island of Bombay.

We may say that the contractors for the whole of the reinforced concrete work were J. C. Gammon (Bombay), Limited, and for the roads, drains and overhead railway Messrs. Raoji Sojpal and Co.

The following details of quantities and areas are of interest :—

Steel rods	54,000 cwt.
Concrete	2,000,000 cubic feet
Length of storm water drains	7.2 miles
Length of fire service mains	4.86 miles
Number of hydrants	165
Number of sprinklers	10,800
Length of railway track	6.75 miles
Length of re-alignment of Harbour Branch Railway	¾ mile
Area of depôt	127 acres
Area of godowns	858 478 square feet
Area of jaithas	627 2?8 square feet
Area of stations	160,120 square feet
Area of Malthoid roofing	931,828 square feet
Area of roads	41 acres

The following analysis shows what proportion the costs of the various constituent parts bear to the total expenditure.

	Rupees.
Godowns	83,70,000
Jaithas	2,45,000
Fire protection	10,00,000
Roads and drains	16,66,000
Railway station and sidings	23,66,000
Re-alignment of Harbour Branch Railway	18,09,000
Offices, &c.	8,06,000
Total	1,62,62,000

The brochure above alluded to concludes by stating that "the new Cotton Depôt, though of sufficient importance to stand by itself as a memorable achievement, is but a link in the progressive development of the Port Trust undertakings, which will, it is confidently expected, soon stretch in an unbroken line along the shores of the harbour to the Island of Trombay, which will be linked up in one great commercial entity. The completion of the depôt, therefore, is a fitting celebration of the jubilee of the Trust, whose progress may be judged from the fact that its revenues have increased from 13 lakhs of rupees in 1873 to 265 lakhs in 1923."

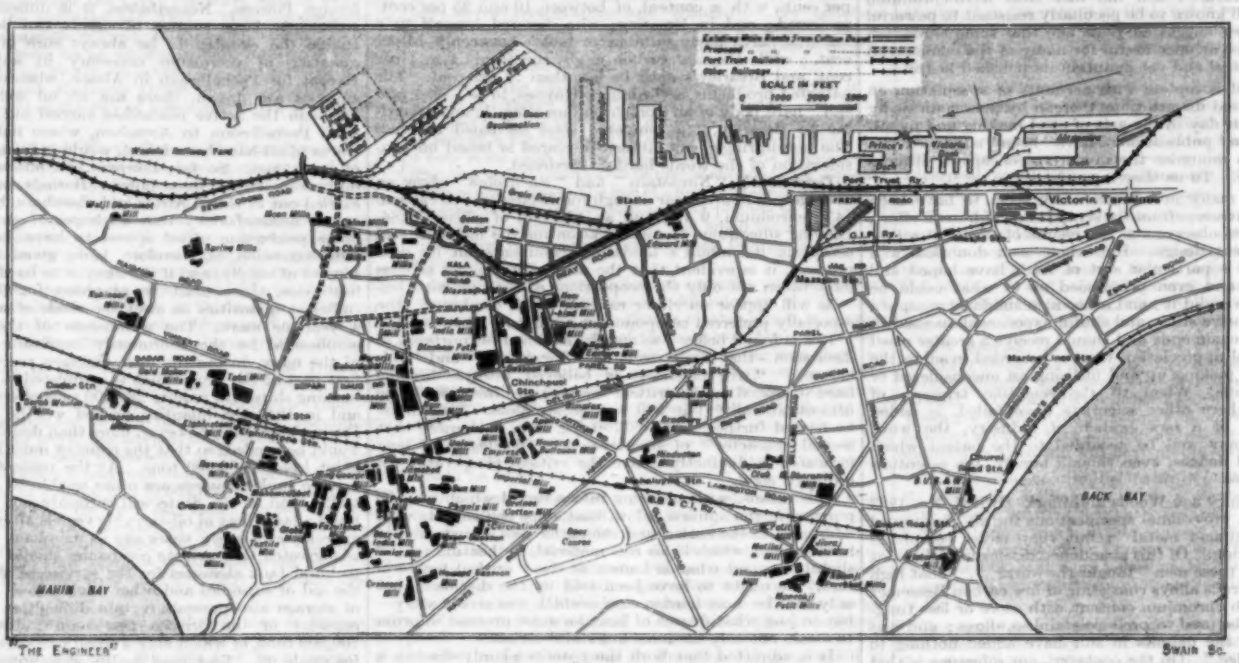


FIG. 4—THE COTTON MILLS OF BOMBAY

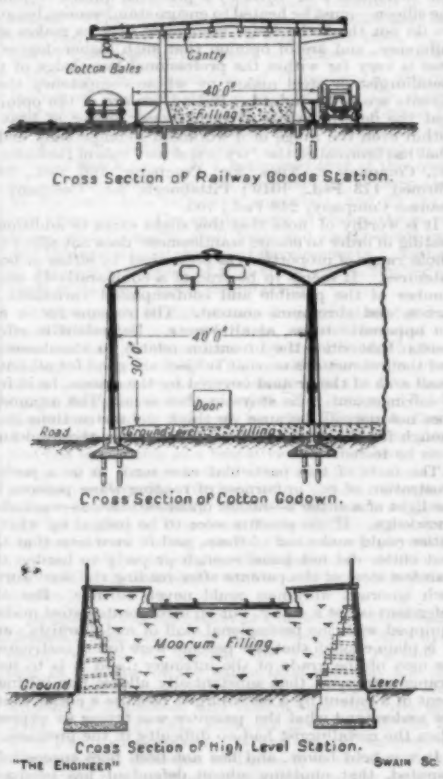


FIG. 5

Stainless Steel Patents.

In our last issue we briefly mentioned the fact that the appeal brought by the American Stainless Steel Company against a previous finding of the United States Courts that the stainless steel products made by the Ludlum Steel Company did not infringe the Brearley patents, had resulted in the former decree being reversed. The judgment of the United States Court of Appeals contains matter of great interest to metallurgists and those concerned with the operation of the Patents Acts, but before passing to it we may briefly state a few facts which will help to make the situation clear.

High-chromium stainless steel was discovered almost simultaneously by Mr. Harry Brearley, of the Brown-Firth Laboratories, Sheffield, and by Mr. Elwood Haynes in America. By a combination of circumstances Mr. Brearley was prevented from obtaining a British patent for his invention. Before it was realised that with this material there was an essential association between its composition and the heat treatment accorded to it, stainless cutlery was being manufactured and placed on the British market. This fact constituted a disability against his obtaining a British patent, but did not do so under the American patent law nor under those of about twenty other countries in which patents were duly applied for and obtained. Both the Haynes and the Brearley patents in the United States are owned by the American Stainless Steel Company.

The Haynes patent was granted on April 1st, 1919, and the Brearley patent on September 5th, 1916. In this connection the Court of Appeals judgment says :—"Although Brearley's patent date is earlier his date of application is later, and it may be summarily held that Haynes' is the generic and Brearley's the specific patent." In the Haynes specification claim is made for "a wrought metal tool having polished surfaces of the incorrodible character of polished surfaces of noble metal, and comprising an alloy of iron and chromium containing from 8 per cent. to 50 per cent. of chromium and from 40 per cent. to 92 per cent. of iron, with carbon in amount between 0.1 per cent. and 1.0 per cent., said alloy being readily malleable and workable and being substantially free of other metals."

Mr. Brearley's specification claimed "a hardened and polished article of manufacture composed of a ferrous alloy containing between 9 per cent. and 16 per cent. of chromium and carbon in quantity less than seven-tenths per cent.

Action was brought by the American Stainless Steel Company against the Ludlum Steel Company on the ground that the latter company's "Nevastain" and "Silchrome" steels infringed the Haynes and Brearley patents. The district court judge, however, held that there was non-infringement of both patents on the grounds that if the disclosure made in the Brearley patent were followed, the Ludlum Company's product would become hard and would not become stainless, and that in the Haynes patent no disclosure was made indicating any method whereby the metal made and sold by the Ludlum Company could be rendered stainless.

In giving judgment in the American Stainless Steel Company's appeal against this decree, the judges of the United States Circuit Court of Appeal pronounced as follows :—

Judgment in this case seems to us primarily to depend on ascertainment of patent validity and scope. This is a prerequisite to determination of the place in the art, or that branch of art, to which the patents belong.

If this invention be found broadly new, meritorious in ingenuity, and lying at the foundation of a wholly novel development of human labour—it should receive in construction a liberality too well recognised to need additional exposition; though we may point out that Treibacher v. Roessler, 219 Fed. 210, is a rather striking illustration of such appropriate liberality.

The history of steel is almost as old as that of commerce, and the story of its use for tools of every kind a commonplace; but equally has it heretofore been a commonplace that unless kept bright by repeated polishing or protected with oil, the steel utensil was expected to lose its lustre—and especially have all steel articles needed protection from the common acids of human food; something usually at hand, and certainly as much needed as steel itself.

The difficulty of producing a steel resistant to what is roughly called "corrosion" even by some of the experts testifying herein, has long been recognised.

That compound of pure iron and the carbide thereof which is steel, has itself been admixed—for many purposes—with other and more infrequent metals; *e.g.*, nickel, tungsten, &c., and chromium. Ferro-chromium is one form of admixture; and the fact that ferro-chromium itself was well known to be peculiarly resistant to powerful acids doubtless suggested years ago that some chromium alloy might be at once useful for many of the commercial purposes of steel and yet maintain its polished lustre.

This record is replete with accounts of speculation on this subject and dissertations thereon by men confessedly skilful in their day in the arts of steel making and metallurgy. These publications have been advanced by defendant to minimise the inventive concept of Haynes and Brearley. To us they magnify it.

There are many inventions which seem to have been gathered, as it were, from the scrap heaps of human effort, they appear to observers as the results of accident rather than intelligent design. But where men doubtless well equipped for a particular sort of work have hoped and investigated and even prophesied as to what could be done, but never did it; and other men similarly equipped have by intensive study and skilful experiment succeeded, such success commands and should receive a greater meed of intellectual appreciation than is accorded even to the cleverness of picking up and utilising an unconsidered or discarded trifle. When to the scientific triumph of succeeding where other scientists have failed, is added development of a new branch of industry, the word "pioneer" may well be accorded to the patent which describes and defines, even though lamely, the essentials of such success.

Half a century ago Woods and Clark (British No. 1923 of 1872) filed provisional specifications for an "improved alloy for anti-acid metal"; but they never completed their application. Of this abandoned disclosure defendant declares that these men "taught the world . . . that high chromium ferrous alloys consisting of low carbon Bessemer steel and high chromium content with more or less tungsten," could be used to produce stainless alloys; and it is urged that "the patents in suit have added nothing to that knowledge." On the contrary, our inference is that Woods and Clark must have thought little of their own concept, as they dropped the matter at once; while examination of their disclosure shows that their preferred alloy for "anti-acid metal" was made in proportions wholly wrong, while their methods of production were merely impossible. They were perhaps among the prophets; but it requires more than prophecy of what may be done, or than declarations of what ought to be accomplished, to make a good patent reference, not to speak of an anticipation. It is necessary to show with reasonable certainty how the desired result can be accomplished. (Westinghouse, &c., Company *v.* Great Northern Company, 88 Fed. 258.)

In 1892 Sir Robert Hadfield investigated chromium steel and published his results. That publication we regard as potent evidence of what were then regarded as insuperable difficulties in attaining permanent lustre in steel. We accept that eminent steel maker's statement, made in 1916, that he in 1892 saw no way of utilising low carbon high chromium steel for making articles capable of remaining untarnished in contact with the common acids.

We have taken from the historical evidence one example of thought expressed in a patent specification, and one of thought expressed in scientific dissertation; the quotations might be much extended, for all the evidence unites to prove that steel of a polished lustre secured by its composition against the commoner forms of acid or corrosive attack, was something sought for, suspected as possible to come from chromium admixtures, but never obtained until contemporaneously in England and the United States, Brearley and Haynes, proceeding along similar lines and having in view substantially the same purpose, produced as a new article of manufacture a wholly novel product, and something almost in denial of previous scientific disclosures, "Stainless steel." To such an inventive concept the often misleading word "pioneer" may fairly be applied.

Having thus given our view of the rank of this inventive thought, the question is crucial—in considering validity. To whom were these patents addressed? Who were the "men skilled in the art" to whom they spoke—and by whose intelligent appreciation they are to be measured as to clarity and sufficiency of disclosure?

Here we are constrained to disagree with the learned District Court; where these patents were measured by what a cutler would learn from them, and more particularly from Brearley. A cutler may mean either a man who makes edged tools, or one who grinds them. He has nothing to do with the manufacture of the steel, which for him is raw material. Yet these patents refer to the production or making of a certain kind of steel; they instruct with remarkable precision as to the component parts of the material, which is to be stainless. It seems to us clear that such a disclosure speaks directly to those whose business it is to make the steel, and not to the cutler who is to fashion it.

We have recently considered the meaning of the phrase "man skilled in the art," and concluded that it is always a relative term; and that no absolute definition of its meaning can be laid down as matter of law; because the query as to who is the man skilled in any particular art is itself a question of fact and one having regard to the patent under consideration. (Dick *v.* Barnett, C. C. A., 2nd, Mar. 5th, 1923.)

It follows that we are of opinion that these patents are to be interpreted in the light of what their disclosures would mean to one accustomed to the art of making steel, or to a metallugist, and not to one who was concerned only with the forming thereof into implements of industry.

What the patentees told metallurgists was that stainlessness might and would be attained by the making of low carbon, and—comparatively—high-chromium alloys when, and only when, what Haynes called "special precautions" were taken in preparation; substantially that crucibles differing from those in ordinary use should be availed of in order to prevent the proximity and consequent admixture of carbonaceous matter during the process of melting. Haynes thought that he could use either electric or fire heat, while Brearley preferentially recommended an electric arc melting furnace. The product of both depended upon the making—under melting conditions as above set forth—of an alloy of iron in which the admixture of chromium was in Haynes to be from 8–60 per cent., with a content of between 10 and 25 per cent. preferred; and in Brearley—who devoted himself to a material particularly suitable for tools—between 9–16 per cent.; while Haynes' carbon might run from .1 to 1 per cent. and Brearley's must be less than .7 per cent. The patented product is, according to Haynes, to be—*inter alia*—a "hard body of an iron chromium alloy"; and according to Brearley, "a tempered steel hardened article." The non-infringement hitherto declared is based on consideration of the words hard or hardened.

Defendant's "Nevastain" and "Silchrome" show an average—in figures near enough for discussion—of carbon, .43; chromium, 9.73; and an addition of silicon, 3.84. Leaving silicon out of consideration for the moment, and accepting defendant's laudatory comments on its own product, it is evident that the alleged infringing articles have taken not only the proportions of both patents, but—as will appear on closer reading of his disclosure—the especially preferred compound or admixture of Brearley.

It was found below—as may be assumed for purposes of discussion—that such steels as "Nevastain" and "Silchrome" "will often—it is believed always—become hard if heated to the critical temperature taken with the utmost liberality but will not be stainless. They must be heated further, and to 1700 deg. Fah. to acquire that second character" of stainlessness. The degree of heat indicated is distinctly above the critical temperature of ordinary steel.

This means, without going into a detail which may be pursued in the opinion below, that since the patents were addressed to the cutler, and the cutler was accustomed to harden steel, which is his raw material, by heating to and slightly beyond what is known as the "critical temperature," he ought to have been told by the disclosure not only that he must harden steel—which was an old story—but to just what degree of heat he must proceed in order to attain not only hardness but stainlessness.

It is admitted that both the patents plainly disclose a hard steel, particularly when the chromium is low; and it is also admitted that the process of hardening generally is not a matter of heating to a fixed point. While it has long been known that the critical point of any steel may be indicated by pyrometric instruments, well known in commerce, it is also proven that even among artisans, including cutlers, the practice of skilled men has been to determine the proper hardening or heating point empirically. We do not go into the exact number of heat degrees above the critical point of ordinary steel to which steels like defendant's or Brearley's preferred product—minus the silicon—must be heated to ensure stainlessness, because we do not think the exact number of degrees makes any difference, and are of opinion that such higher degree of heat is very far within the professional knowledge of the metallurgist or steel maker by whose competency these patents are to be judged. Indeed, we are of the opinion that the determination of such proper degree of heat is within even the range of a workman's competency under what has been called the "try it and see" rule of Bethlehem, &c., Company *v.* Niles, &c., Company, 166 Fed., 880, affirmed 173 Fed., 1019; Pittsburgh, &c., Company *v.* Seaman Company, 248 Fed., 705.

It is worthy of note that this slight extra or additional heating in order to ensure stainlessness does not affect the whole range of proportions as proscribed by either or both patentees. It seems to be true of a comparatively small number of the possible and contemplated variations in carbon and chromium content. The reasons for it are not apparent—to us, at all events. Defendant in effect insists that since the invention relates to stainlessness, and the instructions on that subject are good for all but a small area of the ground covered by the claims, he is free of infringement if he stays in that area. The argument does not prevail, because we think the instructions good enough for the class by whose attainments the disclosure is to be tested.

The facts of this particular case seem to us a perfect illustration of the unfairness of reading these patents by the light of a cutler's—rather under-estimated—workaday knowledge. If the patents were to be judged by what a cutler could make out of them, and it were true that the best cutler did not know enough properly to harden the stainless steel of the patents after reading the disclosures, such ignorant workman could never infringe. But the defendant is not a cutler, but an incorporated steel maker, equipped with the professional skill of metallurgists; and it is plain enough that the patents were full of instruction for men of the grade of the infringer; and it is to us a strange argument that substantially alleges non-infringement of a patent by a metallurgist because a cutler would not understand what the patentee was trying to express, when the metallurgist had no difficulty in the premises.

It was held below, and has not been here successfully disputed, that omitting silicon defendant has produced stainless steel; with the silicon added it has also produced stainless steel; therefore, in respect of infringement the silicon is immaterial, no matter how beneficial it may be.

It was not thought necessary below, and we do not think it necessary to dwell upon the differences between the Haynes and Brearley patents. It is enough for the purposes of this case that defendant's product is within the disclosure of both. Whether there may not be in Haynes an attempt to cover too much ground is a question that may be left until occasion for decision arises.

Decree reversed with costs and case remanded to the District Court for further proceedings in accordance with this opinion.

The French Navy and Oil Fuel.

THE programme for the constitution of a new navy in France, which is to be carried out over a period of eighteen years, cannot be complete unless arrangements are made for ensuring adequate supplies of oil fuel. This is a matter that has long been under consideration, and it is one that must make or mar the efficiency of the French Navy. So far the only assured supplies seem to be those received through participation in the Mossul production under agreement with the British Government. This cession of an appreciable part of the Mossul petroleum to France did not awaken any particular enthusiasm on the other side of the Channel, where feeling is strongly against the navy being dependent in any way upon the goodwill of foreign Powers. Nevertheless, it is difficult to see how sufficiently large sources of supply can be obtained to enable the country to be always sure of securing the quantity of petroleum necessary in any emergency. Except for Pechelbronn in Alsace, whence very limited supplies are drawn, there are no oil wells in France, although the active researches carried out along a zone from Pechelbronn to Arcachon, where natural gas and traces of oil have been found, would indicate the presence of petroleum. So far, however, all efforts at reaching oil-bearing strata have failed. Borings have also been carried out in North Africa and elsewhere, but the results are so unsatisfactory that all hopes of securing a large home production of oil appear to have been dispelled. More attention, is, therefore, being given to the foreign sources of supply, and if the navy is to be effective during hostilities, there must be provision for the storage of sufficient quantities to meet the needs of war vessels for a year or more. The seriousness of the situation is emphasised by the enormously increasing requirements of the navy during the next eighteen years. When the first part of the programme is completed in 1925, the oil-burning ships will require 260,000 tons of crude oil a year, and in 1940 the quantity needed will be 800,000 tons. During hostilities, however, more than double this amount would be needed, so that the country must have a reserve of at least 1,800,000 tons. At the present moment the private tank steamers are quite unable to cope with the traffic, and as the State will certainly not be allowed to build a large fleet of oil-carrying vessels after its disastrous experience of a few years ago as merchant shipowners, it is suggested that private companies should be encouraged to build tank steamers for the service of the State, with the aid of subsidies and other advantages. The question of storage also presents certain difficulties. The storage capacity of the private petroleum industry is about 700,000 tons, of which only a small proportion is available for crude oil. Last year credits were voted for the construction of 36,000 tons of storage tanks. The State must, therefore, be prepared to spend a considerable amount of money upon the construction of tanks, but there is still some indecision as to how this should be done.

In taking measures to supply the navy with oil fuel France, in common with all other naval Powers, is believed by those who have given close attention to oil production to be merely accelerating the inevitable exhaustion of the world's known resources in petroleum. It is only natural that an alarmist view should be taken of a situation which offers so many elements of uncertainty. The consumption of oil is progressing at a phenomenal rate, and so far no new oilfields have been discovered of sufficient importance to suggest a possible continuity of supply. The same alarmist statements were made about coal close upon half a century ago, when the then known reserves were regarded as so far limited that the exportation of a fuel which is indispensable to our industrial prosperity was deprecated. The "oil age" is opening up with much greater limitations so far as natural petroleum is concerned, and it is declared that if the present rate of increase in consumption should continue, the whole of the known supplies will be exhausted in sixty years, while long before that time the inadequate supplies will have so far inflated in values that the industrial use of oil will become impossible. The French are boldly grappling with the problem which they think will be solved by obtaining oil from a source that is being constantly renewed. The Liquid Fuel Congress held in Paris last year showed that the synthetic production of any kind of oil from vegetable produce is not only feasible but perfectly easy. The catalytic process is already regarded as having a commercial value, and will probably be simplified and improved in the direction of reducing costs and increasing production. The only serious impediment to its success is the lack of colonial vegetable products which are at present used exclusively for commercial oils, and one of the objects of the French in developing the African colonies is to ensure the cultivation of practically unlimited quantities of ground nuts and similar products from which oils can be extracted, to be employed for power purposes either by transformation by the catalytic process into oils having exactly the same characteristics as petrol, paraffin or crude petroleum, or else used with little modification for steam raising. Such a result can only be obtained by an intensive colonial cultivation, which would probably take a generation to achieve, but the solution is at least one that limits considerably the risks of a future exhaustion of oil supplies by replacing them with a source that is inexhaustible.

DETAILED figures of the foreign trade of British India for the year 1922–23 show under imports that the United Kingdom exported goods to the value of 14,000 lakhs of rupees, the remainder of the Empire 1619 lakhs, and the United States 1321 lakhs of rupees. These figures represent decreases as compared with 1921–22 of 1092 lakhs of rupees, 1025 lakhs and 840 lakhs respectively. Exports to the United Kingdom amounted to 6527 lakhs, to the remainder of the Empire 5298 lakhs, to the United States 3433 lakhs, representing increases of 1925 lakhs, 774 lakhs and 943 lakhs of rupees respectively. Other principal features were an increase in imports from Germany of 4½ crores of rupees and a decrease in exports from Java of 11 crores of rupees. Exports to Germany increased by 5½ crores, to France by 5½ crores and to Italy by 4 crores of rupees.

Railway Matters.

WE have to announce, with regret, the death, on the 2nd instant, after a severe operation, of Mr. J. J. Brewer, who, after having been the secretary of the London, Brighton and South Coast Company, became the secretary of the Southern Railway Company.

IT is stated that Sir William Acworth has been offered, and has accepted, a commission to prepare a scheme, under M. Zimmerman, the Commissioner-General appointed by the League of Nations to supervise the economic reconstruction of Austria, for the re-organisation of the Austrian railways.

THE Ministry of Transport has recently confirmed two Orders made under the Light Railways Acts of 1896 and 1912 and the Railways Act, 1921. They are respectively the Newcastle-upon-Tyne Corporation Light Railway Extension Order for an additional light railway in the city and county of Newcastle-upon-Tyne, and the Leeds Corporation Light Railways Order for the construction of light railways in the city of Leeds and in the rural district of Hunslet.

THE London and North-Eastern Railway Company has officially announced that it is having constructed at the various manufacturing and repairing shops belonging to the system, *e.g.*, Stafford, Doncaster, Darlington, and Cowlairs, seventy-eight locomotives, 272 passenger coaches, two twin sleeping-cars, six ordinary sleeping cars and 10,635 goods vehicles. Orders have been placed with outside firms for the manufacture of 3630 goods vehicles. It is of interest to note that the order includes three 4–6–2 passenger engines to be built at Darlington. These are, presumably, to be replicas of that illustrated on page 4 and Supplement of THE ENGINEER of January 5th, 1923.

REPLYING to Mr. D. Somerville, in the House of Commons on the 23rd ult., Earl Winterton, Under-Secretary of State for India, said the Acworth Committee did not recommend to the Indian Railway Commission any particular work, but advised that rehabilitation of the railways should take precedence of further development. For rehabilitation it had been decided to spend an average of 30 crores of rupees, or £20,000,000, in each of the five years commencing on April 1st, 1922. Orders for stores and material to the amount of £9,962,500 were placed outside India between April 1st, 1922, and the present time. Of this total amount £9,622,500 were for orders placed with British firms, and £340,000 for orders placed abroad.

THE report of Major Hall on the collision of December 29th at Carlton, North-Eastern Railway, mentioned in this column on January 5th, has just been issued. A steam-worked train of empty mineral wagons was crossing from the up main to the up mineral line when an electrically operated train of loaded wagons overran the down mineral line home signal and ran into the other train. The original of the trouble came about through the driver being told he had a load of 1000 tons, whereas the load was 1400 tons. Apparently the men's societies have been in communication with the Ministry as to the loading of these trains generally, and Major Hall has recommended (1) a compulsory stop at the top of the 1 in 163 bank; (2) a minimum timing over the sections on which there are severe gradients, and (3) a tightening up of the permissive block system in force.

THE only amalgamation under the Railways Act remaining to be determined by the Railway Amalgamation Tribunal is the Caledonian, which is to form part of the London, Midland and Scottish Railway Company. Of the fourteen subsidiary companies to be absorbed in the Southern Railway, there remain the Freshwater, Yarmouth and Newport, the Lee-on-the-Solent, and the Brighton and Dyke: of the twenty-six subsidiary companies for the Great Western, there are the Exeter, Forest of Dean and the Midland and South-Western Junction; of the twenty-seven subsidiary companies to be absorbed in the London, Midland and Scottish there remain the Charnwood Forest, Harborne, Knott End, Lock and Manifold and the Wirral; of the twenty-six in the London and North-Eastern there are the Forth and Clyde, Mansfield, Mid-Suffolk and the Newburgh and North Fife.

AN important announcement as to railway rates was made by Colonel Ashley on the 24th ult. Answering a question by Mr. Remer, he said that he could not agree that application to the Railway Rates Tribunal involved great expense to the traders or other applicants. Its rules of procedure and scale of fees had been drawn up with a view to facilitating access to its jurisdiction. Before the "appointed day," the provisions of the Railways Act afford ample means whereby traders could bring to the determination of the Tribunal questions as to railway charges. When standard charges have been fixed, the Act requires the Tribunal to review the position each year, and while the Minister may direct that after the second annual review a review shall not be held in any year, no such direction may extend to a company in respect of which the Board of Trade has requested that a review shall be made.

IN our "Journal" page last week we announced that the House of Commons Select Committee, which has been considering the proposal for the extension of the City and South London Tube to a junction with the authorised Wimbledon and Sutton Railway, had passed the preamble of that Bill. The Committee then proceeded to consider the junction of the Charing Cross, Euston and Hampstead Railway with the Baker-street and Waterloo in the vicinity of Waterloo Station. It then came out in evidence that the Southern Railway Company had in contemplation the construction of a loop under Waterloo for the reversal of its electrical trains. We wonder if this plan will ever materialise. Of the many such loops proposed only those at the Grand Central Station, New York, at Charing Cross, and at Wood Lane have been opened; that at Boston Southern Station, built twenty-five years ago, has not yet been brought into use. The London Electric Company is not satisfied with that at Charing Cross, as it does not give enough facilities. One was planned for Euston in connection with the electrical services but abandoned.

Notes and Memoranda.

THE consumption of timber in the coal mines of Illinois works out at from 0.09 to 0.39 cubic foot per ton of coal won, and averages 0.23 cubic foot.

TECHNICAL experts state that the air heater invented by the Swedish engineer, M. Ljungström, will render possible a more extensive use of home-produced fuel. Trials with Swedish coal from the Hoegenaes mines are said to have given satisfactory results.

THE untoward effects of almost saturated air with a temperature above 90 deg. Fah. and below 98 deg. Fah. upon men are much less if the air is moving than when it is still. Further, the output or work that can be done is greater when the air is moving than when it is still, with the above temperature and humidity. No beneficial effects are found by moving saturated air at 98.6 deg. or 100 deg. Fah., even at high velocities, and there may be even some disadvantage.

SOME of the limitations of water power are given in an article in *Nature* by Mr. Theodore Stevens. He points out that it would not pay to generate hydro-electric power to supply a lighting load 75 to 100 miles away, if there was a coal mine near the consumers' end of the transmission line; nor was it practicable to undertake to supply separate villages and farms on the line of a high-voltage transmission, because it cost many thousands of pounds to tap power from a high-voltage line, and the small consumption in village and farm cannot possibly pay the interest on this expenditure.

IN concluding some editorial remarks on the present condition of the blast-furnace coke industry, the *Iron and Coal Trades' Review* says that a matter which is causing alarm is the soft quality of the coke now being produced, requiring much more to smelt a ton of pig iron than the harder quality. Soft coke may carry an excessive amount of moisture. These matters, though small in themselves, represent in the aggregate considerable losses during the year. At a time like the present, if the iron trade of the country is to be faced with a serious shortage of coke, every possible means of increasing both quality and quantity should be tried.

THE power generated by the central stations of Italy during 1915 aggregated 1,520,000 horse-power; in 1922 the figure rose to 2,170,000 horse-power. The increase during 1921–1922 amounted to 300,000 horse-power, and during those years 67 new central power stations were opened, of which 15 were provided with reservoirs and artificial lakes. During this same period work was started on 51 new plants, which will utilise 364,454 hydraulic horse-power, and on 27 reservoirs. Important works will shortly be taken in hand in Trentino Venetia, which in three or four years' time will bring the power harnessed to industry up to 3,000,000 horse-power.

INVESTIGATIONS on the action of alkalies on boiler plates, which have been carried out in America indicate that most of the trouble takes place when the boiler pressure is over 150 lb. per square inch, and that embrittlement can be caused by sodium carbonate alone, which, at the high temperature corresponding to that pressure, is decomposed in the boiler into caustic soda. This caustic, it is assumed, then penetrates between the crystals of the steel, forcing them apart and causing hundreds of minute cracks. These cracks are so extremely small that at first they can only be seen with a magnifying glass, but they spread and gradually expand to dangerous dimensions.

THE growing importance of chromium in the manufacture of iron and steel is evident from the statement that the consumption of the metal in the United States increased from 65,000 tons in 1913 to 152,000 tons in 1920; while in 1921, in spite of the depression in trade, it was 110,000 tons. It is estimated that of this quantity 40 per cent. went into the manufacture of ferro-chrome, 35 per cent. into refractory materials, and 25 per cent. into chemicals. The employment of chromium in refractories, and its use in steel frogs and switches for railway and tramway track, are recent developments. Authorities in America are confident that there will be further extensions in its use in metal manufacture.

A TENTATIVE British standard specification for insulating oils for use in transformers, oil switches and circuit breakers has just been issued by the British Engineering Standards Association. This specification is the outcome of an extensive research undertaken in the first instance by the Research Committee of the Institution of Electrical Engineers, and continued by the Electrical Research Association, when that body was formed. The Association has issued this as a tentative specification in the first instance, as the method of conducting the tests is at present undergoing further investigation, every effort being made to simplify the latter as much as possible. The Institution of Petroleum Technologists is also preparing methods of testing oils for the ordinary physical properties, such as viscosity, flash-point, &c., which it is hoped will be available for use in connection with this specification.

IN opening the discussion of a paper on "Heat-resisting Glasses," read before the Royal Society of Arts by Professor W. E. S. Turner, Sir Charles Parsons said that in the case of the gauge tube made by the Schott method in two layers, the inside layer having a less coefficient of expansion and contraction than the outside layer, it followed that when the glass cooled, the inside layer was in compression. It was both in compression in a longitudinal direction and also in a circular direction. Neglecting the longitudinal compression, the inside layer was exactly like the barrel of a large gun, where designedly the coils were either shrunk on or it was wound externally with steel wire, the object being to put the inside in a state of compression within the elastic limit. The result was that when the gun was fired, the tensile stresses became equally disturbed and each concentric tube of the gun bore its share in the stress. He believed this to be the main advantage of the Schott tube, and that it would stand a higher steam pressure than a plain tube. If a plain tube was subjected to heavy internal pressure, the inside layers would be stressed more than the outer, and the stress would be inversely proportional to the radius of the layer under consideration.

Miscellanea.

ACCORDING to the *S.A. Mining and Engineering Journal*, the diamond fields of South-West Africa are likely to have a life of fifty years.

THE recently discovered deposit of torbanite in the Ermelo district of South Africa, it is claimed, has given a yield equivalent to 120 gallons of oil to the ton.

AN agreement has been made for the construction of a shipping port at Cole Bay, Tasmania, and a railway therefrom to the Dalmayne collieries at Piccanniny Point.

THE world's total production of all coal in 1922, according to the United States Geological Survey, was 1,200,000,000 metric tons. This amount was a little greater than the output in 1921, but it was less than in any preceding year since 1915, and less than in the pre-war years 1912 and 1913. The share of the United Kingdom was 255,892,000 tons.

REPRESENTATIONS have been made to the Electricity Commissioners for the postponement of the forthcoming local inquiry at Liverpool, on May 15th and following days. The Commissioners have decided in the special circumstances to commence the inquiry at the Town Hall, Liverpool, at 10.30 a.m. on Thursday, May 17th, instead of on May 15th as previously arranged.

THE East Kootenay Power Company announces that a contract has been let for driving of a tunnel, and other work, in connection with installing the big hydro-electric plant on the Kootenay River near Elko, in British Columbia. It will cost 250,000 dollars to complete. The tunnel will be 2000ft. long, 12ft. by 14ft. inside dimensions, and will be driven largely through solid rock.

THE Cornish tin mining industry is, according to Sir Arthur Carock, passing out of the crisis. Eighteen or twenty months ago there were 9000 Cornish miners out of work. To-day that number has been reduced to 4500. There are eight or ten mines now at work, and it is hoped in a few months that all able-bodied men engaged in the industry in Cornwall will have an opportunity to work.

WE are informed by the Institute of Patentees that the Rt. Hon. Sir William Bull has presented that Institute with a book entitled "What's Wanted," and has opened it by entering what, in his opinion, are the inventions which are needed at the present time. The secretary will be pleased to receive, on behalf of the Council, any suggestions which our readers may care to put forward for record in the book.

THE possibility of utilising the anthracite found in the foothills of the Rocky Mountains in Alberta, north of the Canadian National Railways main line, has been discussed in the Dominion Parliament. It is said that this coal is equal in quality to American anthracite. British capitalists are reported to be interested in the development of the deposits, which are extensive, and can be exploited without deep mining.

AN article in the *Natal Mercury* suggests that the work now being carried out at Durban, South Africa, will result in satisfactory foundations being found for the new grain elevator. After various troubles had been experienced in attempting to make a pile foundation, it was arranged to sink ninety concrete cylinders down to rock level, at a cost of £105,000. This work, also, has been set about with much trouble on account of the instability of the soil, but it is now hoped that it will be completed successfully.

WE hear with pleasure that Mr. H. W. Dickinson, hon. secretary of the Newcomen Society, who is on a visit to the United States, at a luncheon given at the Bankers' Club in his honour, by Mr. L. F. Loree, President of the Delaware and Hudson Company, on April 20th, addressed a number of leading engineering technical journalists and others on the cultural value of the study of the history of engineering and technology and the need for preserving, while there is yet time, objects illustrating advances in science and the arts.

THE reclamation of Back Bay—Bombay's scheme for winning building sites from the sea—proceeds apace. The gantry, which will be eventually replaced by the sea wall, has been completed to a point 5100ft. from the commencement of the work, necessitating the use of 3750 tons of heavy timber work. The rubble mound has been completed for a distance of nearly 3000ft. and further carried out partially for a length of 500ft., requiring the quarrying and railing from Kandivli of 76,000 tons of stone. The mass concrete wall was finished for a length of 1850ft. last season, and operations are about to recommence for the execution of this season's programme of 3000ft.

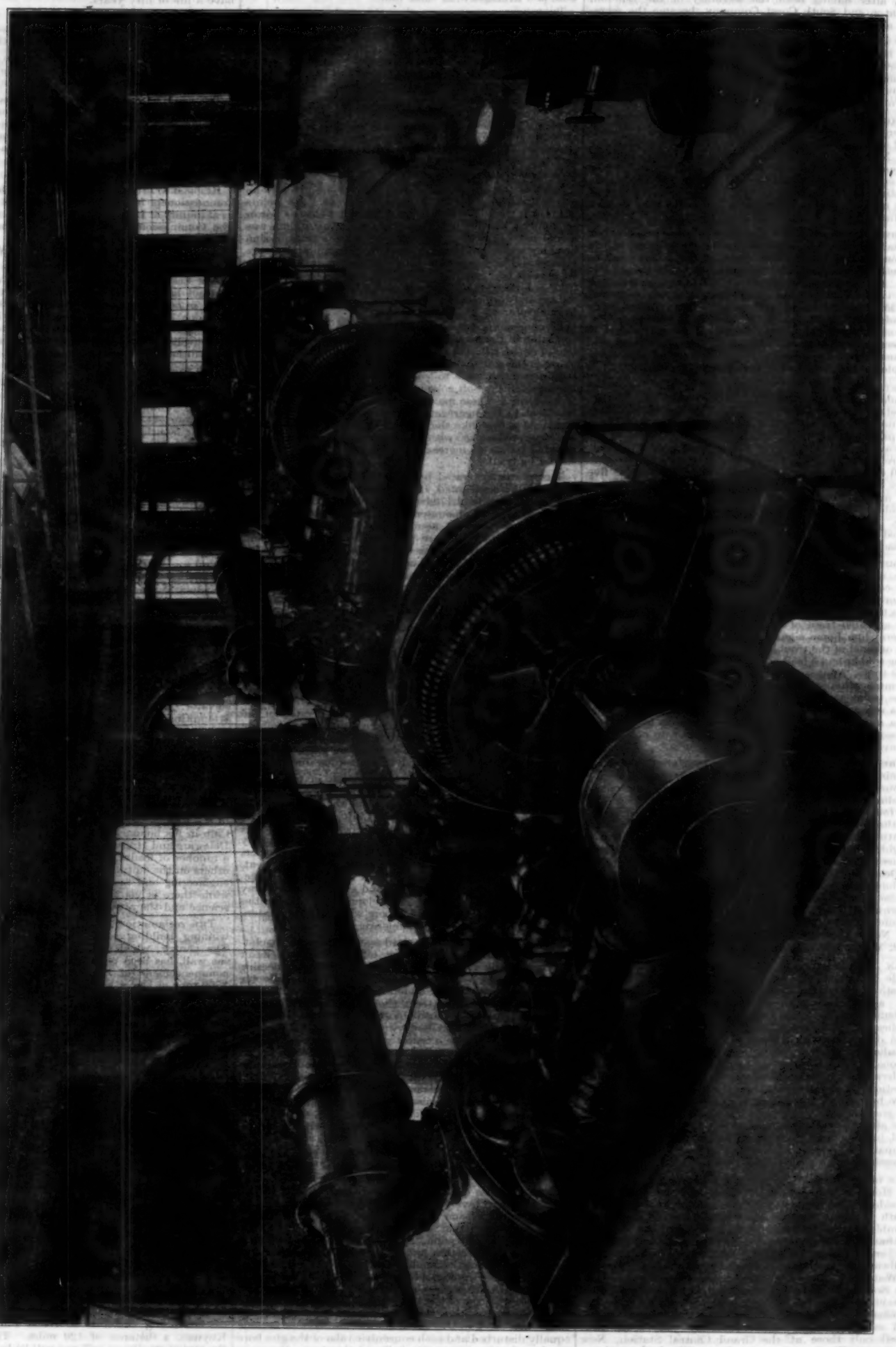
IT is said that Herr Thyssen is taking a ninety-nine years' lease of the Bonn gasworks, and is negotiating with the Municipality to supply Königswinter, Godesberg, Beuel, Honnef and other towns on the opposite bank of the Rhine. He is desirous of acquiring all gas undertakings from Cologne to Mayence, and to monopolise the entire supply over an enormous area on similar lines to those in the Elberfeld–Barmen district. The existing plants are insufficient to cope with the demand. Herr Thyssen is, therefore, seeking to acquire land on the banks of the Rhine for the erection of gigantic gasworks, with water facilities for the transport of coal and the export of coke and other by-products.

ARRANGEMENTS are being made in Kansu, China, for running a service of motor-omnibuses between Lanchow and Haicheng, a distance of about 150 miles. At Haicheng the line is to divide into two branches:—(1) The northern route, which is to pass through Ninganpso and terminate at Ninghsia, a distance of nearly 200 miles; and (2) the eastern route, which is to reach Pingliang by way of Kuyuan, a distance of 120 miles. The road by which the motor omnibuses will run will be built by the Government, to which the company will pay a certain amount of royalty every year. Two new lines are also proposed in Kiangsu, the Kwachow-Tsingkiangpu line, along the Grand Canal, and the Nantungchow-Yangchow line. The distance of the Kwachow-Tsingkiangpu Line is estimated at 100 miles.

ELECTRICALLY-DRIVEN AIR COMPRESSORS AT A DURHAM COLLIERY

THE INGERSOLL-RAND COMPANY, LIMITED, LONDON, ENGINEERS

(For description see page 508)



THE ADMIRALTY ENGINEERING LABORATORY AT WEST DRAYTON, MIDDLESEX

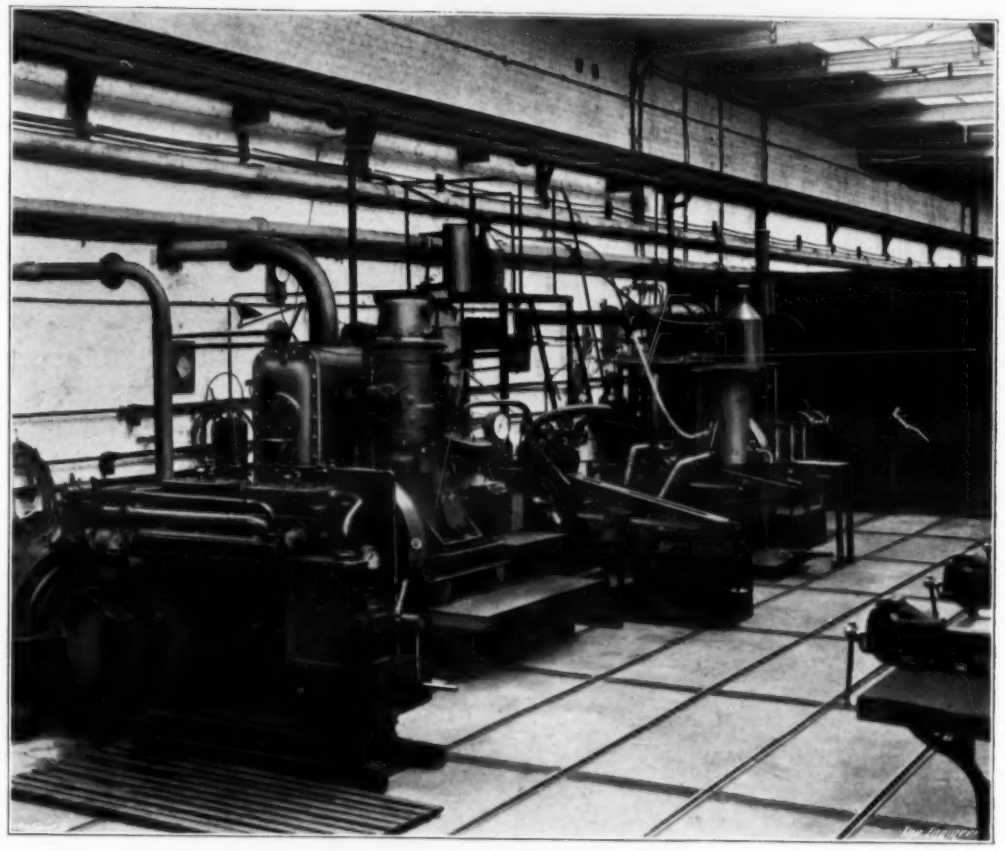


FIG. 1—TESTING BAY FOR SMALL ENGINES

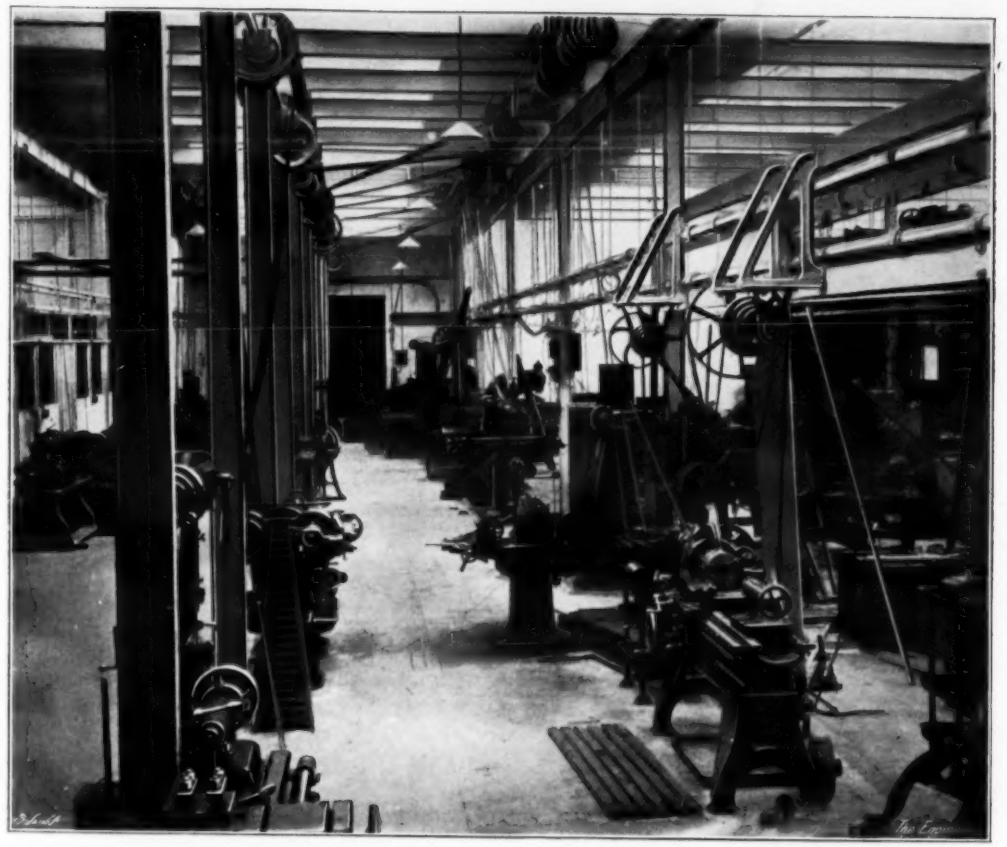


FIG. 2—VIEW IN LABORATORY WORKSHOP

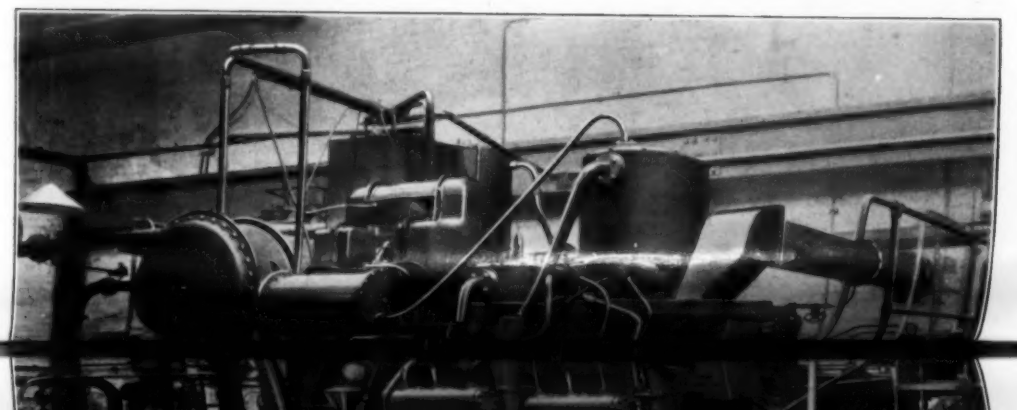


FIG. 3—TESTING BAY FOR LARGE ENGINES

FIG. 4—DOXFORD OPPOSED PISTON ENGINE

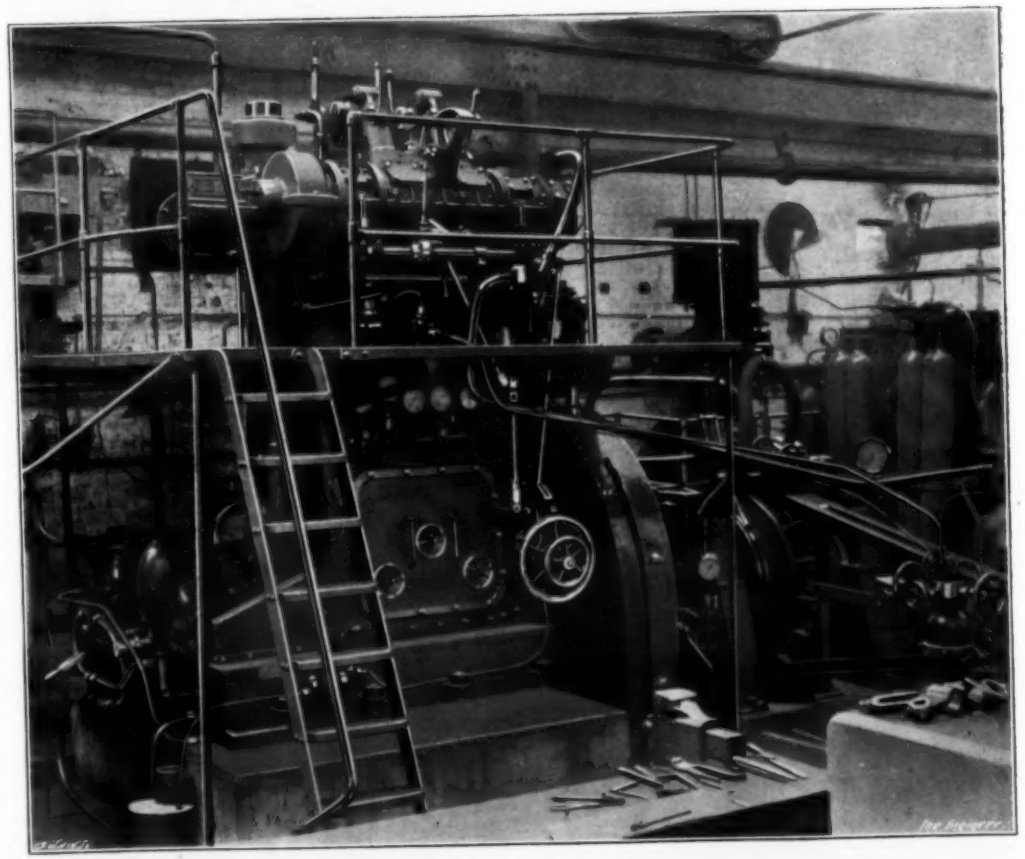


FIG. 5—THE "DIGIT" FOUR-STROKE ENGINE

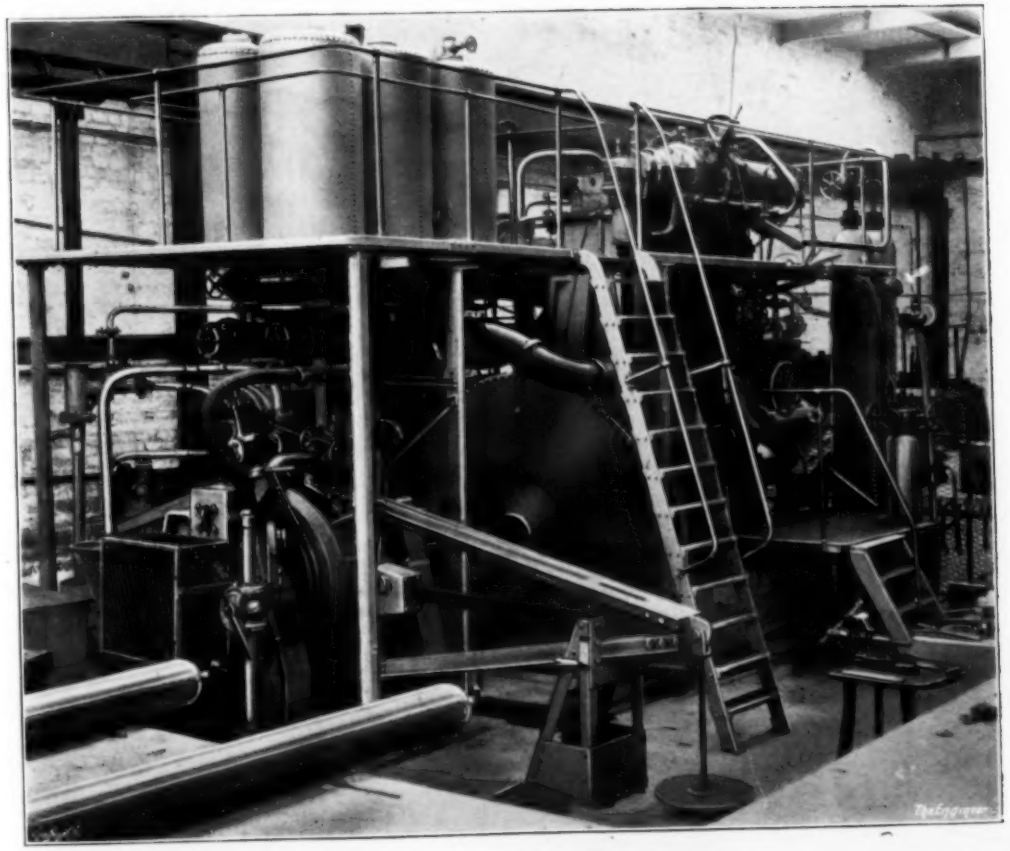


FIG. 6—SINGLE-ACTING TWO-STROKE ENGINE

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PUBLISHER'S NOTICES.

*** *With this week's number is issued as a Supplement a Two-page Plate illustrating the Admiralty Engineering Laboratories at West Drayton, Middlesex. Every number as issued by the Publisher contains a copy of this Supplement, and Subscribers are requested to notify the fact should they not receive it.*

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By arrangement with Reuter's Engineering Service, **The Engineer** *contains the latest news from all parts of the world which is likely to be of interest to engineers.*

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TWO-PAGE SUPPLEMENT—ADMIRALTY ENGINEERING LABORATORIES AT WEST DRAYTON, MIDDLESEX.

THE ENGINEER.

MAY 11, 1923.

Railway Electrification.

ONCE again a paper has been read on the electrification of railways. Before the Institute of Transport on Monday, May 7th, Sir Philip Dawson dealt in a comprehensive way with the financial aspect of the question, and showed that notwithstanding the adverse criticism which was advanced at the time the electrification of the Brighton Company's suburban system was begun, the results obtained with single-phase equipment have more than met expectations. The benefits derived from the electrification of the suburban lines of this company have, of course, been publicly recognised on various occasions. Speaking on February 16th, 1913, for instance, the late Lord Bessborough said that prior to the establishment of electric services on these lines there were 496 trains working in and out of Victoria Station in the day, but the number had since been increased to 739. The corresponding figures for the London Bridge Station were 663 and 901 respectively. Those and other results led the board of directors to look very carefully into the whole question of the suburban traffic, and to consider whether it was advisable to extend electric operation to the remainder of the company's suburban system. This inquiry resulted, as our readers are well aware, in extensive contracts being let, although as the result of the war the greater part of them were subsequently cancelled. On February 15th, 1922, Mr. Macrae, the late chairman of the company, said at the annual meeting that great benefits were expected to accrue from the extension of the electrification, whilst Sir Robert Perks urged the company to go fearlessly forward with a really profitable scheme which would include the two most important points, namely, Brighton and Eastbourne.

In his paper Sir Philip Dawson shows what the electrification of the main line to Brighton might result in. A very thorough and exhaustive investigation, which took over two years to complete, has been carried out with a view to ascertaining the financial results which would follow the extension of the suburban electrification to the coast. To operate the main line electrically, the whole of the suburban system would first have to be equipped, but as a result of the use of 11,000 volts, which would then be adopted, little additional expenditure would be required on that portion of the system. The investigation mentioned involved the preparation of a complete electrification scheme in detail, a scheme which is said to have shown that, taking the total cost, including the suburban and main lines, and comprising line equipment, transmission lines, sub-stations and rolling stock and its equipment, together with all the track and station alterations and allowing for interest during construction, the ratio between the capital expenditure involved in the suburban and main line electrification would be as 7 is to 4. The total cost of operating the suburban lines as compared with that of working the main line traffic would be as 7 is to 3, and if the gross receipts resulting from the suburban and main line electrification were increased in the ratio of 2 to 1, the net receipts in the two cases would be in the ratio of 7 to 6. It has been assumed in arriving at all the preceding conclusions that the carrying capacity would be increased 140 per cent. in the case of the suburban system and 70 per cent. in the case of the main line system, and based on the capital expenditure involved and the operating costs, and with the fares in force in 1922, an increase in gross receipts of 70 per cent. on the suburban sections and 35 per cent. on the main line would show a return of 8½ per cent. on the capital expenditure needed to carry out the scheme. Each further increase in the gross receipts of 20 per cent. on the suburban sections and 10 per cent. on the main line represents an additional 3½ per cent. on the capital expenditure. The relatively smaller cost involved in completing the electrification scheme to the coast and the larger average fares realised, bring the fact to light that the most attractive portion of the scheme can only be reached when electrification to Brighton is completed. From the foregoing summary survey it will be perceived that the paper contains instructive facts, based, as we have said, upon an exhaustive and careful investigation. The excellent results that have been obtained on the Brighton Railway, and the still better results which are anticipated when electrification is extended, are, it is important to note, associated with a system which was at one time described by a prominent electrical engineer as a monstrosity. As Dr. S. P. Smith remarked during the discussion, single-phase working has proved to be good under conditions for which it is generally considered to be unsuitable, namely, on suburban lines. The question that naturally arises and which incidentally was not dealt with in the discussion—probably because most of the speakers were not electrical men—is whether, under the present conditions and neglecting the question of extensions, direct current could give better results. It would certainly be interesting to know whether there are still any engineers, apart from those connected with firms which have never taken the trouble to study single-phase traction, who believe that the adoption of the single-phase system on the Brighton lines was a mistake. It was suggested by one speaker that as the direct and alternating schemes now seem to possess equal merit, the question of which system to adopt might be settled once and for all by a "toss up," but Dr. Smith thought that there was a grave possibility of the wrong system being adopted. The fact of the matter is, of course, as we have repeatedly emphasised, that every case of electrification must be carefully considered individually and that standardisation at this juncture is inexpedient. Not many years ago Sir Philip Dawson was almost the sole supporter in this country of the use of single-phase traction on main lines. To-day, however, there are many who, if not staunch advocates of the system, are certainly not antagonistic to it. Speaking at the meeting last Monday, Sir Philip Nash said that he was one of the individuals who signed the document authorising the Brighton Company to extend its single-phase system, and he did so for two reasons. In the first place, the lines which had been electrified were working quite well, and, secondly, it was a good thing, he thought, that there should be some single-phase electrification in this country. The second reason given by Sir Philip Nash is unquestionably an extremely good one. It is not only in this country that the large electrical firms have to seek trade. There are many places abroad where railways will be electrified, and it is not to be imagined that firms which are devoid of single-phase experience will invariably find no difficulty in getting the work. All the talk about the high cost of maintaining the overhead equipment and the motors, and telegraph and telephone interference, will not serve in the future to persuade everyone to adopt direct current, for, as Sir Philip Dawson says, and as reference to past issues of THE ENGINEER will show, very many miles of railway track are now worked with high-pressure alternating current.

By a strange coincidence, an interesting report has, at the moment of writing these lines, come to hand from the Westinghouse Electric and Manufacturing Company of America, stating that the company has just entered into a contract with the Virginian Railway for the complete electrification of the line between Mullens and Roanoke, in the

State of Virginia. The contract involves the electrification of 134 route miles and 215 miles of track. The line will handle a very heavy coal traffic with 600-ton trains on a 2 per cent. gradient and 900-ton trains over the remainder of the line. The contract includes the supply of 600-ton split-phase 25-cycle 11,000-volt locomotives of the most powerful type so far contemplated, and the electrification scheme is said to be the largest of all that have up to the present been undertaken. Hence it will be seen that even in America, where, in common with this country, there is much diversity of opinion concerning the method of electrifying railways, alternating current is not by any means being discarded, and it behoves all large electrical firms which are anxious to secure a fair share of electrical railway work thoroughly to familiarise themselves with the manufacture of alternating-current equipment.

Abstract Science and the Engineer.

The audience which gathered at the Institution of Civil Engineers on Friday last to hear Sir Richard Glazebrook's "James Forrest" Lecture was smaller than usual on these occasions, but it listened with the closest attention to the words of the eminent lecturer. The title of Sir Richard's discourse—which we print in an abridged form on another page—was "The Interdependence of Abstract Science and Engineering." In that title we see the recognition of a fact which is not uncommonly overlooked. What engineering owes to science is frequently insisted upon, but rarely does anyone describe what science owes to engineering. Even Sir Richard went but little further than his title in this respect. Science could have made very little progress indeed had it not been for engineering, and we suggest to the Institution that next year it should seek the services of a lecturer who would deal with this neglected aspect of "Interdependence." There is not a single scientific laboratory that does not owe the construction of its apparatus, and frequently the details of its design, to engineers, and not a single observatory that could carry on its observations without the aid of engineers. Vast testing machines are the products of engineering firms, and the very light, heat and power upon which the scientist depends for his observations are provided by the products of the engineer and controlled by him. Hardly a thing used by the abstract scientist from the high compressors of Dewar to the millivoltmeters of Bragg but has passed through the engineers' shops, and could not have been produced but for the practical knowledge which has been accumulated by a long race of engineering craftsmen and designers.

The point we have been endeavouring to make in the preceding paragraph has a significance greater than appears on the face. It enables us to realise the folly of attempting to estimate the respective value of two things so closely related that separation is impossible. We have shown that science is dependent upon the engineer, and that engineering is dependent upon science no one would think of denying. It is a notable fact that as soon as anything becomes commonplace by use we are apt to forget its scientific origin. The common pump of the gardener was in its day a scientific apparatus, and the discovery of its mode of working was a scientific event of the highest industrial import. Even in the boiling of eggs science must be called into operation, and the production of that exact degree, between hardness and softness, that is required in certain culinary preparations, can only have been discovered by a research which was no less scientific because it was conducted in a kitchen instead of a laboratory! The despised rule-of-thumb is found on investigation to be no more than a scientific observation which cannot be proved in the terms of other observations. But as, sooner or later, a point is reached in the other observations where they themselves cannot be explained, it is only removed in degree, not in nature, from the highest science. It is only when we set up limiting definitions that we approach grounds for reasonable argument. We may speak of "abstract" science as meaning science of which *at the time* no industrial application is seen, and of "industrial" science as that which is directed to the immediate improvement of some manufacturing process. But even then there is so much overlapping, such a wide indefinite bounding area between them, that an estimate of relative value is as far off as ever. Since Sir Richard included the word "abstract" in his title and advanced the Alloys Research as an example, we are probably right in assuming that he regards the work of the National Physical Laboratory in this subject as abstract science. Now, all the specimens were tested for those very qualities that would render them useful in the arts, and their industrial value is certainly always before the mind of the Committee by which the research is directed. Hence, it seems to us, the research is concrete rather than abstract. A far more typical example on which the lecturer spent some time was the investigation into the propagation and reception of electrical waves. That was unquestionable abstract science to begin with, but further research must of necessity be industrial. The example, however, is not a very rich one, because the relationship between wireless transmission and engineering is rather distant. A more intimate example might have been sought in the connection between abstract science and the development of the steam turbine and internal combustion engine. But, unfortunately for Sir Richard's argument, the influence of abstract research in these two subjects has been small. Black's investigation into Latent Heat was, of course, abstract, but Watt's further inquiries must, within the terms of our definition, be regarded as "industrial." The bulk of the improvement in both prime movers is the outcome of trial and error and progressive development. The original gas engine was produced when there was little or no abstract science about combustion, and it is very doubtful if all the admirable researches of scientists have done more for its development than rationalised knowledge obtained by experience, and provide us with mathematical means of proving that our efficiencies are as high as can be rationally expected. The Diesel engine began with an idea, based on a familiar lecture experiment and a handful of mathematics, and was developed by hard workshop slogging at mechanical engineering problems. Carnot's general principles certainly affected men's thoughts, and thereby possibly inspired progress, but his famous law to which Sir Richard also referred, has done little, if any, more for heat engine design than stopping men from making fools of themselves by searching for the impossible, and providing engineers with a means of stating efficiencies. The locomotive, again, owes little or nothing directly to research of any kind, either abstract or industrial. It has been hammered out of experience in the laboratory of the world. No one ever thought of superheating as a "scientific" invention until a German professor took it up. The ship and the aeroplane, on the other hand, owe a great deal to research; but for the greater part it has always been research directed to a definite object, and not therefore abstract. To the most brilliant example of all in support of his argument, the lecturer devoted very little, if any, space. Faraday's inquiries were pure abstract science of the highest order, and must remain, until the useful application of atomic energy is realised, the finest instance of the value of pure science to engineering. Other examples could, of course, be found, but none so good as this. We suggest for consideration Michel's inquiry into lubrication which led him, we believe, to the invention of his thrust block, or Andrews' investigation into the liquefaction of gases, which may be regarded as originating the carbonic acid gas process of refrigeration.

This very superficial review of the position is, we trust, sufficient to show how useless it is to argue about the value of pure science in any particular direction. Mechanical engineering, as we have seen, owes relatively little to it; but, on the other hand, electrical engineering is founded on it, and in the domain of chemistry and physics endless examples of its value may be found. We must not judge the value of scientific discoveries by their immediate industrial return, and perhaps we are even wrong in attempting to justify science by exhibiting cases where it has been turned to unanticipated uses. It is better that it should be allowed to stand on its own merit. The increase of knowledge is in itself and by itself a great and admirable thing. It is something to be proud of, something to honour men for. It requires no justification. What would we think of one who endeavoured to evaluate the merits of Shakespeare's sonnets by the possibility of converting them into cinema films, or of using quotations from them to advertise hunting boots? One thing, moreover, of which we may be certain—if we cannot be content to enjoy science for the love of it—is that sooner or later a use will be found for it, and that its immediate promulgation, by enlarging men's minds, opens new vistas before their imaginations and leads to a general intellectual condition which prepares the world for the next forward movement.

The Interdependence of Abstract Science and Engineering.*

By Sir RICHARD TETLEY GLAZEBROOK, K.C.B., M.A., D.Sc., F.R.S., Hon. M. Inst. C.E.

I wish in the first place to express my cordial thanks to the Council for the honour conferred on me by the invitation to deliver this lecture. The secretary wrote, telling me of the subject of the first lecture delivered by Sir William Anderson thirty years ago, "The Interdependence of Abstract Science and Engineering," and stating that "the President feels that this would be a good opportunity to deal with scientific research in relation to engineering practice, and especially with the organisation, methods and application of engineering research." I welcomed the opportunity. Some twenty happy years of life had been spent in the attempt to apply science to industry, chiefly engineering industry; and the thought of being able to speak on such a subject in this hall was an alluring one. I accepted gladly, but without reading Sir William Anderson's lecture; when I studied it, I was appalled at the task lightly undertaken. His lecture covers an immense extent; it rests on the experience gained in a long and active life devoted to his profession; it is illustrated by reference to questions and difficulties outside my ken; it is full of knowledge obtained by the study of many problems in science and economics and by the application to these of an acute and critical mind. I cannot hope to treat the subject in a manner which will bear comparison with the skill and ability applied to it by my predecessor. Still, I will do my best: let me commence by quoting the conclusion of his lecture:—

"I have endeavoured to show," he said, "how the history of abstract science by which I intend to designate the history of researches entered into for the sole purpose of acquiring knowledge of the operation of Nature and her laws, without any thought of reward or expectation of pecuniary advantage, has had its reflex in the records of the engineering profession, and how the most recondite investigations, apparently unlikely to have any direct influence on our practice have, in course of time, become of cardinal importance. I have also ventured to point out how in these days the engineer must banish from his mind that idea that anything can be too small or too trifling to deserve his attention. 'Nothing is too small for the great man' is, I am told, written over the cottage once occupied by Peter the Great at Saardam. The truth embodied in that legend should ever dwell in our minds, for success, I am persuaded, lies largely in close attention to details."

Or, again, referring to the views of Mr. Forrest himself:—"You cannot touch anything in natural science which will not, sooner or later, prove of advantage to the members of this Institution, and which the engineer will not, in time, turn to the moral as well as to the material advantage of the human race."

The experience of the last thirty years has all tended to confirm these views. It is my task to-night to give some few illustrations of the truth of the principles advocated by Sir William Anderson, and to trace some of the effects those principles have had on engineering practice. This effect has shown itself in many forms. The education of the engineer has been greatly modified in consequence. Institutions devoted to the application of science to industry have grown and multiplied. The State has recognised something of its responsibility; and private persons, public men, and industrial associations have given many proofs that now their importance has been, at least in part, realised. As one of the most striking of these proofs let me mention the recent generous gift to the Royal Society of Sir Alfred Yarrow, a gift intended for the advancement of abstract science—natural knowledge—to use the phrase by which it is known in the Charter of the Society.

By establishing the William Froude tank at the National Physical Laboratory, and by the researches which led to the water-tube boiler and the torpedo-boat destroyer, Sir Alfred had already shown his appreciation of the value of science. May I, as a scientific worker, rather than as an engineer, thank him for all he has done.

The National Physical Laboratory.

Before discussing in detail some of the modern applications of abstract science to engineering, Sir Richard referred first of all to the work of various educational bodies, including the Imperial College of Science and Technology; the University of London; the Royal Technical College, Glasgow; the University of Manchester; the Manchester Technical College; the Engineering School at Cambridge, &c. &c. Then, speaking of the application of science to industry, he continued:—It is not improper, I trust, for me to place first the National Physical Laboratory, and I do this the more readily, speaking in this hall and to this audience, because of the intimate connection which has existed between the Institution and the National Physical Laboratory since its foundation. Your representatives on the General Board of the Laboratory have

* The Institution of Civil Engineers. The "James Forrest" Lecture, May 4th, 1923. Abstract.

been your Past-presidents—Sir John Wolfe Barry, Sir William Preece, Sir William White, Professor Unwin, and Sir Robert Elliott-Cooper. Nor are these all the members of your Council who have given unstinted help. Dr. Maw has served for long on the General Board and Executive Committee; Colonel Crompton, ever young, is almost a perpetual member, and his enthusiasm has inspired and supported many of our most interesting undertakings. Sir Benjamin Baker, Sir Andrew Noble, Sir Frederick Donaldson, Sir Maurice Fitzmaurice, Captain Sankey, Sir Henry Oram, Sir John Aspinall, Sir Archibald Denny, Sir Robert Hadfield, Mr. Alexander Siemens, Sir John Snell, Sir Alfred Yarrow, Sir Charles Parsons, Sir Dugald Clerk and Sir William Ellis are some of those to whose assistance success is due. Mr. Basil Mott, the designer of the Froude tank, has helped our work in a marked degree.

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The scheme of organisation was admirably adapted for its ends. The ultimate control was vested in the President and Council of the Royal Society, who were to act through a general board and an executive committee. The board consists of certain official members, six in number, and thirty-six ordinary members appointed by the Council of the Royal Society. Of these twelve are nominated by the six leading technical societies*; the remaining twenty-four are selected by the Council from men of science and leaders in industry and trade, who need not be—many indeed are not—Fellows of the Society. The executive committee of twelve, with certain officials, is appointed from the board with the proviso that half the ordinary members must be selected from the representatives of the technical societies.

The executive committee was to have the immediate management of the Laboratory, and was responsible for its finance. The director was responsible to and took instructions from the executive committee, but, subject to such instructions, had the sole direction and control of the officials of the National Physical Laboratory and of the work done within it. Such was the scheme, and under this scheme the Laboratory worked until 1918. Sir Arthur Rücker and Mr. S. E. Spring Rice, of the Treasury, took the main part in its preparation, and it is a privilege to put on record my testimony to the value of their work.

But in time the building spread beyond its foundations. Conditions during and after the war altered; the financial responsibility became too great for the Royal Society to bear. In 1900 the ordinary expenditure was £5479; by 1913–14 it had grown to £38,003; and since the war it has largely exceeded that amount. The value of the work done for which payment is received now approaches £100,000.

Thus a change was necessary, and in 1918 the Laboratory became a Government institution: the responsibility of the Royal Society ceased. The general board and the executive committee, though appointed by the President and Council, are responsible to the Department of Scientific and Industrial Research; the real control rests in the hands of the officers of the department and of its Advisory Council.

During the period 1900–1914 thirteen volumes of scientific researches were published. We began in a small way with two departments—Physics and Engineering—and a staff at the end of 1901 at Bushy House, of the director, eight scientific assistants, an accountant, four mechanics, and an engine-driver—in all fifteen people. In addition, Kew Observatory, with Dr. Chree and a staff of sixteen, formed the Observatory Department.

The Department of Scientific and Industrial Research.

A Committee of Council dealing with industrial and scientific research came into existence first under the auspices of the Board of Education, when Mr. Pease was President of the Board. At a later date it was connected with a department of its own. On December 1st, 1916, a deputation from the Conjoint Board of Scientific Societies, headed by Sir Joseph Thomson, President of the Royal Society, waited on Lord Crewe in this hall. Sir J. J. Thomson, in his address, dealt with the importance to industry of research in pure science; he was supported by Sir Maurice Fitzmaurice, the President of this Institution, speaking on behalf of engineering, and by Professor H. B. Baker, F.R.S., who dealt with some of the problems of industrial chemistry. In his reply Lord Crewe, Lord President of the Council, outlined some of the duties and responsibilities of the new department.

The following is an extract from the official notice issued at the time—December 1st, 1916:—

"The Government have decided to establish a separate Department of Scientific and Industrial Research for Great Britain and Ireland under the Lord President of the Council, with the President of the Board of Education as Vice-president. They have also decided, subject to the consent of Parliament, to place a large sum of money at the disposal of the new department, to be used as a fund for the conduct of research for the benefit of the national industries on a co-operative basis."

The sum of money placed at the disposal of the department for this co-operative work was £1,000,000, and is held in trust by the Imperial Trust for the Encouragement of Scientific and Industrial Research for the work of the industrial research associations referred to in more detail in another section of his address. But, in addition, the department controls other agencies and administers further funds devoted to the application of science to industry. The National Physical Laboratory is considered elsewhere, the Geological Survey and Museum is also one of the activities of the department, while under the Fuel Research Board and the Food Investigation Board problems of vital interest are being investigated.

Further work of great importance is dealt with by the Co-ordinating Boards for Chemistry, Physics Engineering, and Radio Research established by the direction of the Government to co-ordinate researches which are of value to the fighting services, and which also have industrial applications. The researches are carried out at the National Physical Laboratory or at other research establishments, usually under Government control, though to some extent university laboratories are made use of. In addition to these, there are a number of boards dealing with special problems, the work of one such—the Lubrication Research Committee—is of utmost importance to engineers; while finally the department applies a portion of its funds to grants to research workers and students at the universities. The lists of aided researches and of publications by individuals in receipt of grants, given in the appendixes to the report, show the wide extent of this branch of its activities and its importance to industry.

The British Engineering Standards Association.

Among the many agencies which in recent years have contributed to the application of abstract science to industry the British Engineering Standards Association holds a prominent position.

It was formed in 1901 at the instance of Sir John Wolfe Barry, who until his death held the position of chairman, when six of eight members were nominated by this Institution to investigate the question of steel sections. The organisation now numbers some 2000 members and over 400 committees. It has issued about 170 specifications, covering a wide field. Standardisation is based on accurate measurement, and in the preparation of many of these specifications fundamental principles have been evolved and researches of difficulty and importance have been required.

Private Research Laboratories.

Another most valuable method of applying science to research is the research laboratory of a large firm, and though of necessity the work of such a laboratory is aimed mainly at improving the products of the firm, the fact is being realised more and more that for this purpose also investigations into pure science are essential. I need hardly do more than refer to the chemical investigations which have formed the basis of the German dye industry or the researches of Haber and his colleagues on the nitrogen problem—an inquiry advanced here in England by the work of the nitrogen products branch of the Ministry of Munitions.

Perhaps the best known of the engineering research laboratories controlled by an industrial firm is the establishment at Schenectady of the General Electric Company of America. The research section of the Westinghouse Electric and Manufacturing Laboratory is organised somewhat differently. It is divided into sections and embraces work from the purely theoretical side of the problems presented to the practical application of principles and problems in the factory. The laboratory of the Eastman Kodak Company affords another instance of the union between pure science and industry; it is sufficient to refer to the work on light filters which has proceeded from it, and the improvements thereby rendered possible in every branch of photography, and not least in the microphotographic work so important to the engineer.

In England there are few such great laboratories, and for this there are various reasons. In a recent address, in which he stressed the importance of psychology to the worker, Lord Balfour wrote:—"As a nation we have underrated the great work which science can do for industry We are too apt to think that science is only for men of science, and that learning can interest only the learned." The war has taught us another lesson, and the necessity of close co-operation with science is fully realised in every branch of industry. In a publisher's circular recently received, it is stated that:—"Whatever the commodity, if it be of any considerable importance, the factory producing it without the scientific guidance of a closely-allied laboratory is working blindfold."

But there were pioneers who recognised this long since. Manganese steel was produced in 1882 from the laboratory of Sir Robert Hadfield, in Sheffield, as the result of a scientific inquiry into the properties of alloys; and many results of high value to science have come from the same source. The foundations of photomicrographic research were laid by Sorby in a Sheffield laboratory, and the Brown-Firth laboratories of John Brown and Sons have for some time past been engaged under Dr. Hatfield on fundamental researches into the properties of alloys of steel. In Manchester there are important laboratories attached to the Westinghouse works, and electrical engineers know the value of the researches which go on there, while many of my audience who were present at the opening ceremony of the new laboratories of the General Electric Company at Wembley some few weeks back must have gained a new conception of what is meant by a works laboratory, and of the interdependence of pure science and electrical engineering.

A research laboratory is not complete unless it contains members interested in almost every branch of science and provides facilities for these and also other classes of work. This wide branching of research, starting originally from an apparently restricted problem, has an incidental advantage. It makes a laboratory which is fitted to undertake one kind of industrial research fitted to undertake all. It is true that there is a certain amount of specialised equipment such as the laboratory factories, which form part of the organisation, and which are necessary to bridge the gap that separates research from its successful incorporation in factory production. These are a very important part, because failure at this point may render, and often has rendered, useless magnificent efforts on either side of the gap. But they are a small part and, whatever be the needs of the future, the research laboratories can readily direct their efforts to any point from which the new call comes.

But laboratories such as this are possible only to the favoured few. In the case of any but the richest firms the cost would clearly be too great. While a works laboratory in which routine tests are applied to the materials used and products manufactured is a necessity even in the case of small firms, these can only secure the advantage of pure research by some form of co-operation; and it is to meet this case that the research associations of the Department of Scientific and Industrial Research have been evolved.

Wireless Telegraphy.

Up to the present, obedient to the President's behest, I have dealt mainly with the organisation and methods of engineering research, but my address would be singularly incomplete if I did not attempt an account of some of its recent results and of its marked progress. And here my real difficulties commence. Statistics and the kindness of many friends have made the earlier portion of my task comparatively light.

But now the difficulty is what to select, where to begin. Let me deal first, briefly and incompletely it must be, I fear, with that branch of electrical engineering—radio, or wireless telegraphy—which at present exercises such a fascination over the popular mind, which is already and will be to a greater extent in the future a link to bind together all nations of the earth. Sir William Anderson refers to Preece's early experiments between Lavernock and Flatholme, a distance of 8 miles, as a startling consequence of electro-magnetic theory. Now the earth is girdled with a wireless chain depending from two, or at most three, great stations. I have just received from the International Union for Scientific Radio Telegraphy details of a scheme for the determination of longitude in which the principal co-operating stations will be Bordeaux, Annapolis and Pearl Harbour. In the year 1865 Clerk Maxwell read before the Royal Society his paper on "The Equations of the Electro-magnetic Field." It was an attempt which has stood the test of time—the conditions which led Lorentz and, later, Einstein to introduce certain modifications were not considered by Maxwell—to apply mathematical reasoning to those principles, enunciated by Faraday, on which the construction of generators and motors, transformers and practically all electrical machinery is based. This reasoning led him to the result that the effect of changes in an electric current in a conducting wire would be propagated through space with a speed depending on the two constants which define the electric and magnetic conditions of the medium surrounding the wire. The values of these constants for air can be found from electrical considerations, and hence the velocity with which electro-magnetic disturbances are propagated can be calculated. To quote his words: "We now proceed to investigate whether these properties of that which constitutes the electro-magnetic field, deduced from electro-magnetic phenomena alone, are sufficient to explain the propagation of light through the same substance"; and his conclusion is: "The agreement of the results seem to show that light and magnetism are affections of the same substance and that light is an electro-magnetic disturbance propagated through the field according to electro-magnetic laws." Maxwell found that when the calculations were made the resulting value for the velocity was approximately equal to the velocity of light.

The method of generating the waves and the means for measuring them were still to come. For the former we have to go back to a remarkable paper by a very distinguished honorary member of this Institution, Lord Kelvin. Helmholtz seems to have been the first to conceive that the discharge of a condenser through a wire might consist of a forward and backward motion of electricity between the coatings—a series of currents in opposite directions. Sir William Thomson took up the question mathematically and investigated the phenomena. David Hughes, working in the early 'eighties, had already detected such oscillations, but was discouraged from pursuing the subject.

* These are the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Iron and Steel Institute, the Institution of Naval Architects, and the Society of Chemical Industry.

In 1879, in consequence of the offer of a prize by the Berlin Academy, the attention of Heinrich Herz, then a student under Helmholtz, was drawn to the problem of electric oscillations and their detection. He came to the conclusion that with the means of observation then at his disposal "any decided effect could scarcely be hoped for, but only an action lying just within the limits of observation." The investigation was laid aside only to be revived in 1886 by a chance observation of the effect of resonance in two circuits which happened to be in tune, and his realisation of the fact that herein lay the means of solution of his problem. The great man and the not-too-small theory of the first James Forrest Lecture had met. His paper "On Very Rapid Electric Oscillations" appeared in Wiedemann's "Annalen," Vol. XXXI., for 1887, and from the experiment came verification of Maxwell's theory, the basis of all our knowledge of wireless.

Fitzgerald called the attention of English physicists to the work at the British Association meeting in 1888, and Lodge exhibited many of the effects of the waves at the Royal Institution in 1889. The investigations which led to such brilliant results were inspired by the desire for knowledge. The idea of their practical application was entirely absent. Signalling by wireless waves was not foreshadowed until Crookes suggested it in 1892, and in 1893, the year of Sir William Anderson's Lecture, Lodge heard of Branly's coherer and applied it to the rectification and reception of wireless waves. From this started the investigations of many of those whose names as pioneers are familiar to all. But another discovery in pure science was necessary to complete the work.

Edison had shown in 1883 that if an insulated electrode was inserted in an ordinary glow lamp there was a current of negative electricity from the filament to the electrode—the emission of negative electricity from a hot body had been observed by various experimenters—and Fleming made some observations about this date on the Edison effect. In 1904 he applied them to produce a valve rectifier for high-frequency oscillations by connecting one pole of his receiving circuit to an insulated plate or cylinder within a carbon lamp, of which the negative electrode forms the other pole of the receiving circuit. When the filament is made incandescent, negative electricity can readily pass from it to the insulated plate and hence into the receiving circuit. The flow of positive electricity in the same direction is checked; the lamp has a rectifying action.

Dr. Lee de Forest improved this oscillation valve a little later, making it an amplifier as well as a rectifier by placing between the filament and the plate or cylinder a grid of metal wire connected to an external source of electromotive force, by means of which its potential can be varied. There is ordinarily a current of negative electricity passing from the filament to the plate—the plate current it is called—through the interstices of the grid. By varying the potential of the grid, this current can be varied, and the conditions can be so adjusted that small changes in the potential of the grid will produce large changes in the plate current. The plate current is passed through the primary of a step-up transformer, in the secondary of which is the receiving telephone, and the effect is thereby made audible. The grid is connected to one pole of the circuit receiving the incoming waves, and the small variations of potential which they produce thus give rise to large variations of the plate current, and hence the sound is amplified. By placing a number of valves in series very large amplications are possible.

The Properties of Materials.

After referring at some little length to the vacuum tubes of Crookes and to the properties of electrons and various rays, Sir Richard directed attention to the properties of materials. Few matters are, he said, of more importance to the engineer than the properties, metallurgical and others, of the materials he uses in his structures, and for the knowledge of these he owes everything ultimately to the researches of the seeker after new knowledge. From the time when Sorby applied the microscope to the study of metals and alloys, and Roberts-Austen, and Osmond investigated their heating and cooling curves to the present day, there has been continuous progress. Much of this is due to the investigations of the Alloys Research Committee of the Institution of Mechanical Engineers, and a comparison of the earlier reports of that Committee with the eleventh report just issued from the National Physical Laboratory shows in an interesting manner the extent to which modern industrial processes rest on pure science and how great is the debt incurred since those early days.

For some time the Committee has worked on light alloys, impelled to it in part by the need to develop these for use in aircraft. It is good to learn that, thanks in great measure to the generosity and zeal of Sir John Dewrance, the Committee has been reconstituted so as to be more widely representative, and intends in the future to direct its work to the study of ferrous alloys. It is hoped to prepare alloys of iron with other metals, such as chromium and cobalt, which shall be free from carbon, and then to go on to more complex materials. As the memorandum, in which Dr. Rosenhain brought before the Committee the proposals for this work, states: "It may confidently be expected that work of this kind, which has never been attempted in this systematic manner before, is likely to lead to results of a far-reaching importance and to the evolution of materials likely to be of very special value to the mechanical engineer." To me it is a matter of very real pleasure that the greater part of the work will go on at the National Physical Laboratory.

Investigations Regarding Lubrication.

Reference was then made to the work of Osborne Reynolds and the late Lord Rayleigh on the resistance of bodies moving through fluids. Closely connected with the results they achieved, and even of more importance perhaps to engineers, is the investigation on lubrication described by Dr. Stanton in his recent Thomas Hawksley Lecture before the Institution of Mechanical Engineers. Dr. Stanton, Sir Richard explained, has recently succeeded in measuring the pressure in the film over an arc of contact of from 14 deg. to 15 deg. for various oils under a total load of 690 lb. at a journal speed of 1000 revolutions per minute. The maximum pressure for castor oil was 3.5 tons per square inch, and the resultant of the vertical components of the pressure approximately balanced the load. At their nearest point of approach the surfaces were only 0.000046in. apart, while the coefficient of viscosity agreed with that found by Mr. Hyde. Thus the experiments showed that the laws of hydrodynamics hold, and are competent to account for the observed facts, even in a film which is $^{5}/_{1000000}$in. in thickness, and which is subject to a pressure of 3.5 tons per square inch.

The Elastic Properties of Materials.

Of great interest to any engineer is a knowledge of the elastic properties of the material with which he deals, and of the changes which go on in the material when the limits of its elasticity are exceeded. For the study of these properties, various forms of extensometer have been devised. Professor Dalby's work in this field is well known, and he has himself described his load-extension elastic instrument, which, by a skilful combination of the principle of the weigh bar and magnification by the aid of photography, gives a complete record of the elastic properties of the specimen under test in the course of a few minutes in a form which can be readily reproduced and kept for study at leisure.

Thirty years ago Sir William Anderson referred to the phenomenon of fatigue in engineering materials, as shown in the breaking of locomotive axles, screw propeller shafts, and other parts subject to alternating or rapidly varying conditions of stress. Since that time much abstract science has been applied in the attempt to elucidate the problem, and many methods of determining the fatigue limits have been devised. It must suffice here to refer to the ingenious model, by the aid of which Professor Jenkin, of Oxford, has been able to illustrate the mechanism of failure, and to give a reasonable explanation of many of the principal phenomena observed, and to mention the modification of the well-known Wöhler method of determining the fatigue limits devised by Mr. Gough, of the National Physical Laboratory. A stainless steel mirror is attached to the specimen in such a manner that it is at right angles to the axis. A small source of light which can move along a vertical scale is adjusted so that its image is visible in a telescope having its axis horizontal and directed to the mirror. When the specimen is unloaded, the light remains visible as it rotates. If a load be gradually applied, the specimen bends, and the light is shifted so as always to remain on the cross wire of the telescope. Its position can be read to 0.01in. If the scale-reading is plotted against the load, a straight line is at first obtained, followed by a deviation turn when the limiting range of stress is reached. The time taken for an observation varies from ten minutes to half an hour, depending on the rate of loading; but in any case the reduction of time from that needed for the old method is very great.

Aeronautics.

No branch of engineering owes more to abstract science than aeronautics. Lord Rayleigh's work on dynamical similarity is at the base of all wind-channel work on models. In a wind-channel the forces on a model aircraft due to its motion relative to the air, or the thrust and torque of a model propeller, are measured, and from these, using the principle of dynamical similarity, the corresponding full-scale effects are inferred from the assumption that they are proportional to the square of the linear dimensions and the square of the speed. Strictly this implies, as we have seen, that the quantity $f\left(\frac{V\,L}{\nu}\right)$ has the same value for model and full scale. Thus either this quantity is constant or $\frac{V\,L}{\nu} = \frac{V_1\,L_1}{\nu_1}$, where the subscript refers to the full scale. Since air is in both cases the surrounding medium, $\nu = \nu_1$, and we must have $V\,L = V_1\,L_1$. This, however, is impossible if L is necessarily much less than L, and it is impossible to make the speed in the wind channel proportionately greater than that of the full-scale machine. We are driven, then, to the first alternative, that for a strict comparison $f\left(\frac{V\,L}{\nu}\right)$ must be a constant.

Experiments such as Dr. Stanton's on flow of air and water in pipes, and the actual measurement of the forces on models at different wind speeds, show that this is very approximately true in most cases. Airship models of good performance form an exception to this statement; but the corrections required to model results are now generally accepted, and there is a gratifying agreement both between different wind channels and the conclusions from model and full-scale experiments. However this may be, the problem of the flow of air round an aeroplane is no easy one, and there is ample opportunity for abstract science to influence still more engineering practice.

The Internal Combustion Engine.

The development of the internal combustion engine is another engineering problem which owes much to exact science. Its foundation is contained in the celebrated memoir of Sadi Carnot: "Réflexions sur la puissance motrice du feu et sur les machines propres a développer cette puissance," published almost exactly one hundred years ago—Paris, 1824—in which he sets out "to establish reasoning applicable not only to steam engines, but to every imaginable heat engine, whatever be the working substance and whatever be the manner in which it is employed"; and is led to the remark, "wherever these exists a difference of temperature there can be a production of motive power."

It is a long journey from this, either through the steam engines of his day—Carnot refers in particular to the high-pressure engines of Trevithick and Vivian (*deux habiles ingénieurs Anglais*)—working at pressures of 8 or 10 atmospheres, but without condensers—to the turbine which now drives our 20,000-ton liners, or through the primitive hot-air engine of Stirling or the early Otto machines, to the Rolls-Royce and the Napier "Lion" of modern aeronautics.

In this work many have combined to help. Perhaps I may mention specially the Light Alloys Sub-Committee of the Aeronautical Research Committee, the work of the Metallurgical Department of the National Physical Laboratory, and of Professor Lea, of Birmingham, with the Internal Combustion Engine Committee of the British Association, which numbers among its members men so well known to this Institution as Sir Dugald Clerk (Chairman), Professors Callendar, Coker and Dalby, and in days gone by inspired much of the work of Bertram Hopkinson on the explosion of gases. To Callendar we owe the platinum thermometer, which has added so greatly to the accuracy of thermometric work. His work and that of Dalby, with his ingenious device for inserting the thermometer in the cylinder at the right instant, have rendered possible the determination of the temperature at each stage of the engine cycle, provided we can draw the indicator diagram, and this the researches of Dalby again have made possible. As a result of all this we can obtain in any case the materials for drawing up a heat balance sheet for the engine, while in quite recent years the work of Ricardo has indicated means for securing a greater efficiency, especially at high altitudes, and much light has been thrown on the problem of detonation by his investigations, combined with those of Fenning.

The Steam Turbine.

And, to return to the steam engine, Sir William Anderson, in his Lecture, referred to the rude and cheap apparatus with which Watt in the astonishingly short period of two years, "furnished himself with the abstract knowledge required for explaining in a definite manner the action of the steam engine," and then "had no difficulty, as soon as his theoretical ground was sure, in determining what mechanical arrangements were necessary to realise the conditions imposed by science."

I have neither the time nor the skill to trace in detail the steps by which the genius of Parsons was led to develop the turbine, or to narrate the history of its growth from the Turbinia to the present day. The main facts are these. In 1897 the Turbinia, of 44½ tons displacement, 100ft. in length, attained a speed of 34 knots during the Naval Review at Spithead. The shaft horse-power was about 2100 and the revolutions 2000. Ten years later came the Mauretania and Lusitania with four propellers and a shaft horse-power of 70,000; while in H.M.S. Hood—1919—there are four separate sets of turbines, each driving a propeller through gearing, with a total horse-power of 144,000.

As in Watt's steam engine, so in the turbine, we see the work of a man "who is a born mechanic as well as a seeker after physical knowledge"; the combination of the two is required for any real advance in engineering science.

And now to conclude. There is much more that might be said, many more instances in which the discoveries of abstract science have been the foundation of the triumphs of the engineer, but I have trespassed sufficiently on your time. I have given you, I trust, sufficient examples to prove the interdependence of the two. Modern civilisation is based on abstract knowledge, and all experience goes to enforce the dictum of my predecessor thirty years ago, that "the days are past when an engineer can acquit himself respectably by the aid of mother-wit alone, or of those constructive instincts" which in the past led our predecessors to such brilliant results.

A Coupling for Road Wagons.

A NUMBER of suggestions have been made, from time to time, for the utilisation, in road transport, of a locomotive unit in conjunction with a series of receptacles for the goods to be carried, the object being to free the locomotive from unprofitable delays at the termini where the freight had to be handled, and to keep it in more or less continuous service in the essential function of hauling. The problem has, of course, been complicated by the regulations that control road traffic, and limit the speed and weight of vehicles according to whether they are trailers or are self contained.

Loose bodies on a lorry meet some of the requirements but necessitate facilities at the termini for their handling, while simple trailers suffer from the disadvantage that they are handicapped by the speed limit. The last mentioned drawback does not apply so seriously in the case of six-wheeled vehicles, while it is obvious that this type embodies two distinct units that might be employed to advantage if each were separately mobile. The objection to such a scheme has, however, been the amount of time and labour entailed in removing the body portion of a six-wheeler and replacing it by another unit. But we have recently witnessed some demonstrations with a vehicle which seems to meet all requirements in this direction.

This machine, which has been made to the order of the War Department by Messrs. Hobdell, Way and Co., Limited, of Hendon, and is illustrated by our half-tone engravings and line drawings, is really an adaptation of recognised standard units. The tractor, or locomotive part, is a modified A.E.C. petrol lorry, while the body is a special form of Army service wagon. These two parts may each be used quite independently, but may be also joined together by one man, in the course of one or two minutes, to form a six-wheeled vehicle.

The apparatus used in the coupling together of the two parts and in the conversion of the body into a mobile vehicle, are obviously the most interesting items, and we therefore give details of them to the exclusion of the more standardised parts.

The coupling for joining the body to the tractor—illustrated by Fig. 1—takes the form of a ball and socket, and is mounted on the rear of the tractor. The tractor is a standard 4-ton lorry, with the frames shortened at the back and provided with a bearer to carry the socket. The ball, which is about 5in. in diameter, is fixed to a casting bolted to the centre of the end transom of the body. On reference to Fig. 1, it will be seen that the socket embraces the ball well beyond the greatest diameter, so that there is no possibility of the ball jumping out accidentally. In order, however, to permit the two parts being separated the socket is made of two pieces, each of which is pivoted in the main casing. The front half, A, is pivoted about B, while the rear portion C rocks on D. It will be noticed that the vertical centre line of the ball is appreciably behind the centre of the pivot B, with the result that the weight of the body tends to turn the part A in a clockwise direction. Movement in this direction is, however, limited by the stop E, while the spring plunger F tends to keep the part A up against this stop. Movement of the half socket in the opposite direction is prevented by the trigger G, which can be disengaged by pulling on the wire rope shown. The rear half of the socket C cannot open in a clockwise direction, as it is checked by the tail end resting on the casting at H, and there is no tendency for it to turn the other way while the ball is in the socket.

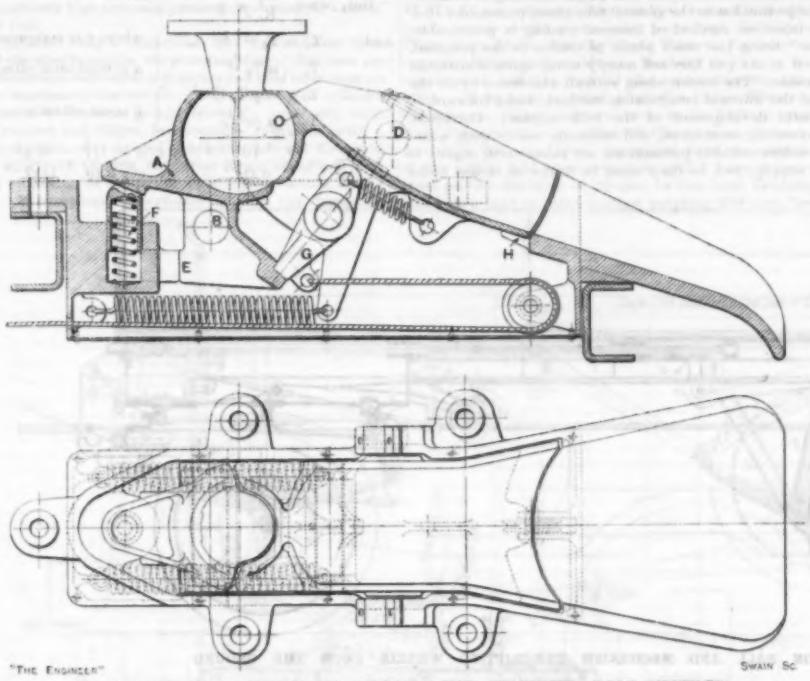


FIG. 1—PLAN AND SECTION OF COUPLING FOR SIX-WHEEL ROAD VEHICLES

If it be desired to take the ball out of the socket, that is to say, uncouple the body, the trigger G is released by pulling on the rope that leads to a handle beside the driver. The tractor is then driven astern slightly, with the result that the half socket A is rocked about its pivot in an anti-clockwise direction, compressing the spring plunger until it comes against the stop. The ball will then be quite clear of the back half socket C. If the pull on the trigger rope is continued the back end of the trigger will meet the back of the socket, and the trigger will act as a lever for rotating the part C about D until its top lip is brought below the ball. Then, if the tractor is moved ahead, the ball will jump out of the front half socket and slide down the ramp to the rear. When the trigger rope is released the springs reset the socket in the position illustrated. In coupling up it is only necessary to back the tractor until the ball runs up the ramp. The weight of the body then depresses the rear half socket until the ball slides into the front half, when the main spring closes the socket. It should be observed that the centre of the ball is in the same horizontal plane as the axis of the pivot D, so that the tractive effort has no tendency to rock the rear half socket about its pivot.

The whole device is of a good substantial design that appeared to us to be capable of withstanding the rough usage that is generally the lot of petrol wagons. The body and ball are mild steel castings, while the jaws of the socket are gun-metal. The ball is drilled down the centre and provided with a Stauffer lubricator. The two views—Figs. 2 and 3—show the coupling ready set and the ball in the act of dropping into the socket.

In order to make the body independent and mobile when it is uncoupled from the tractor, it is provided with four wheels, but only two of them are in use when it is working with the tractor as a six-wheeled vehicle, as shown in Fig. 4. It will be noticed that the front pair of body wheels is then raised off the ground. For this purpose the wheels are mounted on a set of swinging links, as shown in the line drawing, Fig. 5. These links are marked A, B and C. A and B are pivoted at their top ends in brackets on the main frames, while the upper end of C is attached to a crosshead D. This crosshead can be moved in horizontal slides by means of the screw E, which is operated by a winch handle at the rear of the body. The arrangement of the links is such that a powerful toggle action is provided for forcing the wheels down on to the road and thus taking the load off the ball and socket connection with the tractor. When the wheels have taken the load the catch F engages with the crosshead D, and thus relieves the screw E of the load. The screw is, however, reversed slightly so as to lock B, C and F as a rigid triangle. To lift the wheels off the ground, when the body is coupled with the tractor, the catch F is released and the screw turned to bring the links into the positions shown by the broken lines. The other arm G, of the catch F, then hooks under the axle and again relieves the screw of load. A wire rope for controlling the catches is led to the rear of the body handy to the man working the screw.

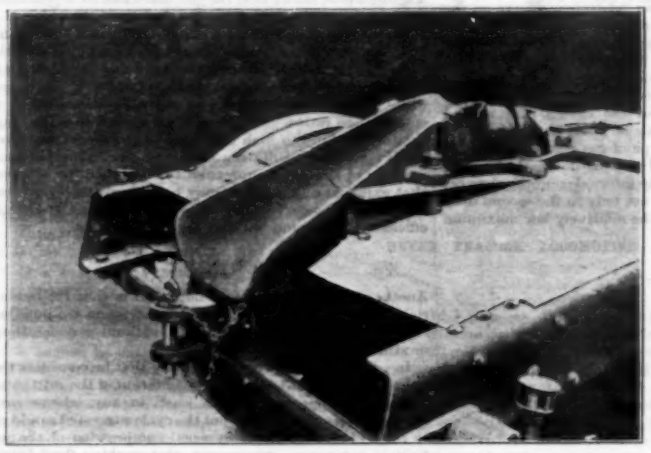


FIG. 2—THE BALL RAMP AND SOCKET ON TRACTOR

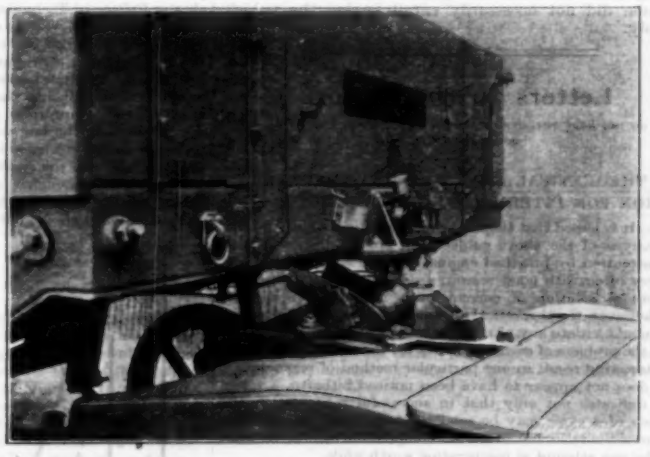


FIG. 3—THE BALL ON TRAILER ABOUT TO ENTER SOCKET ON TRACTOR

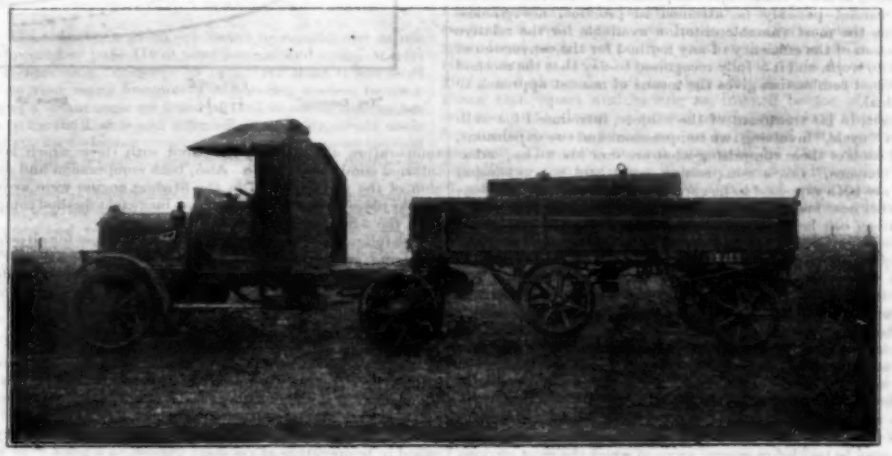


FIG. 4—TRACTOR AND TRAILER CONNECTED TOGETHER

The two rear wheels are mounted on a turntable that is provided with keys for locking it in the normal position, which is, of course, necessary for the six-wheeled form of service. The rear wheels are fitted with internal expanding brakes that can be operated either from hand wheels on the sides of the wagon, or by a wire rope connection with the tractor. The vehicle is equipped with ordinary draw gear at each end, while the turntable is arranged for a pole and standard horse draught gear. It will thus be seen that the arrangement of the wagon to act as the body of a six-wheeled vehicle in no way interferes with its service as an independent unit.

The overall dimensions of the wagon are 14ft. 6in. by 7ft. The unloaded floor height is 4ft. from the ground, and the useful load 4 tons, while the unloaded weight is 2 tons 9 cwt. The wheels are of steel, arranged with floating bushes and provided with solid rubber tires 880 mm. by 120 mm. The flexibility of the connection between the tractor and body is fairly obvious, and permits an up and down movement through an angle of 10 deg. on either side of the vertical, while horizontally

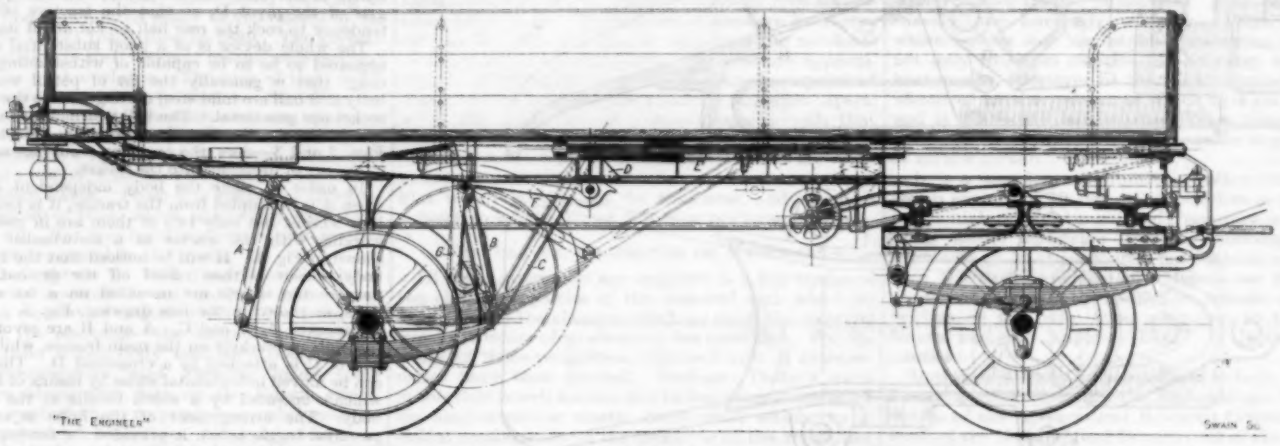


FIG. 5—TRAILER SHOWING TRACTION BALL AND MECHANISM FOR LIFTING WHEELS FROM THE GROUND

the tractor and body can be turned until they are at right angles to one another. Coupling and uncoupling can be effected with the two parts at any angle, and is naturally carried out with the brakes on to steady the body. We noticed during our inspection that with an ordinary degree of skill in steering the driver had no difficulty in getting the ball into the socket at the first shot, and that the operation did not necessarily entail jarring the vehicle seriously.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE THEORETICAL ASPECT OF HEAT REGENERATION FOR INTERNAL COMBUSTION MOTORS.

SIR,—It is hoped that the following theoretical considerations and analysis of the above subject will not be dismissed with slight attention by practical engineers. The latter sometimes, and very often with good reason, are apt to treat such paper attempts at solution of current problems as too academic. Here, however, the theoretical analysis involves no assumptions which might vitiate any of the conclusions reached. Investigation of the problem of regeneration has led the writer to a curious and interesting result in one particular method of regeneration which does not appear to have been noticed hitherto, a result which indicates not only that in successful regeneration the efficiency of a cycle may be rendered practically independent of compression ratio, but that a low compression ratio is essential to render any attempt at regeneration worth while.

Engineers by this time have fully realised the importance of the fundamental principle enunciated by Sadi Carnot in 1824 in his famous "Reflections on the Motive Power of Heat." Briefly and practically put, the principle is that for highest efficiency of conversion of heat into work the paramount aim should be to supply all the heat at as high a temperature as possible, and at the other extreme, discharge the unconverted portion at as low a temperature as possible. While the ideal set forth cannot possibly be attained in practice, nevertheless it forms the most valuable criterion available for the relative estimation of the efficiency of any method for the conversion of heat into work, and it is fully recognised to-day that the method of internal combustion gives the means of nearest approach to this ideal.

Carnot, in his treatment of the subject, introduced his well-known "cycle," involving two compressions and two expansions, one of each of these comprising what are now known as "adiabatic changes," *i.e.*, a compression event and one expansion event are both supposed to be carried out under ideal conditions of neither heat loss nor heat gain during the process. Such ideal conditions can be approached more nearly than is commonly supposed, particularly so in internal combustion engines of the high-speed class, where the time of compression and expansion are so short that heat conduction effects are but small. The other two events in Carnot's cycle, one compression and one expansion, are what are now known as "isothermal changes," *i.e.*, changes under constant temperature conditions. These are not attempted now in practice owing to the well-established fact that, while leading to high efficiencies in conjunction with the other two adiabatic events, they, at the same time, result in very low mean effective pressures.

The regeneration method of securing economy by the utilisation of the usually discarded heat in the exhaust gases and jacket water may be tackled in several ways, of which the most obvious are: (*a*) to divert the heat to another source of supply, such as a steam boiler, and utilise it in another prime mover, either a reciprocating engine or turbine unit; (*b*) to divert the heat back again to the original source of supply, this portion being thereby partially converted into work and so increasing the engine efficiency.

The "Still" engine, now well on the development stage, is the most recent example of a determined effort to secure economy by the first means. The scheme involved is already well enough known without requiring detailed description here. To the writer's mind more gain would be realised by applying the principle of internal cooling by water injection and utilising the heat energy in the resulting mixture of steam and exhaust gases in an atmospheric turbine. Theoretically, at least, he has shown* that the efficiency gain would be appreciably greater. The method also has the merit of being more direct and involves no duplication of function as is the case in the Still engine scheme. The chief objection lies in the general reluctance to consider that the water injection method of internal cooling is practicable, "corrosion" being the main plank of critics to the proposal. [The above is not put forward merely in the spirit of criticism for its own sake. The writer, along with all who desire to see the advance of the internal combustion method, looks forward to the successful development of the Still engine.] Corrosion, under adverse circumstances, will certainly occur with water injection, unless suitable precautions are taken with regard to the water supply, just as they must be taken in steam boiler work. The writer does not consider that serious corrosion will arise owing to sulphur contents in the fuel used. That bogey has already been shattered with regard to the sulphur content of petrol, for which it has been shown that a relatively high sulphur content has practically no tendency to induce corrosion. The writer and others carried out a practically continuous series of tests with water injection† on a Crossley gas engine at the Manchester College of Technology, and no deleterious effects on the engine valves and cylinder surfaces were ever observed.

The second method of securing regeneration, *i.e.*, by diverting the heat back to the original source of supply, suffers from two difficulties. The first is the evolution of a suitable mechanical method of introducing the preheated portion of the supply gases at the appropriate portion of the cycle. The second difficulty lies in the low conductivity of gases and therefore a tendency to low efficiency in any type of gas regenerator. The classic instance of the application of this method is the Stirling hot-air engine, although it is not of the internal combustion type. Its low efficiency was due, however, not only to the second difficulty mentioned above, but also to the relatively low maximum

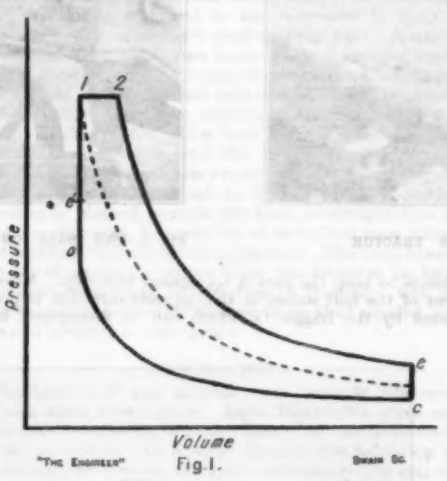


Fig. 1.

temperature of the cycle compared with those which hold in internal combustion work. Also, both compression and expansion of the working fluid in the Stirling engine were arranged to take place isothermally, always an inefficient method compared with the adiabatic method.

The following cycle is suggested as a basic one for all schemes involving gas regenerators. The diagram *c a 1 2 e* of Fig. 1 represents the usual dual combustion cycle, divided by the dotted line into the normal constant volume combustion cycle or gas engine cycle, below, and the Diesel or constant pressure combustion cycle, above. If the exhaust gases discharged at temperature T_e are to be used to heat up the supply gases, the most that can be done, theoretically speaking, is to raise the latter by some type of regenerator, also to temperature T_e. In this case the regenerator does not require to be of unit efficiency, since the exhaust heat discharged is equal to $K_v (T_e - T_a)$, while that given to the supply gases would be (assuming that they are raised in temperature at constant volume to a point *d* at which the temperature is also T_e) equal to $K_v (T_e - T_c)$. But T_c is greater than T_a, hence the heat to be given to the gases is less than that available in the exhaust. This means that the possibilities of carrying out the regeneration to this degree are enhanced and are certainly much greater than in the Stirling engine method. The interesting point about the cycle of Fig. 1, however, is the form of its efficiency expression. The writer is not aware that this particular case has been previously suggested or investigated. The efficiency of the complete cycle *c a 1 2 e* under constant specific heat conditions is given by

$$\eta_i = \frac{\text{Work done}}{\text{Heat received}} = \frac{K_v (T_1 - T_a) + K_p (T_2 - T_1) - K_v (T_e - T_a)}{K_p (T_1 - T_a) + K_p (T_2 - T_1)}.$$

But, since $\frac{K_p}{K_v} = \gamma$

and

$$T_a = T_0 r^{\gamma - 1}$$
$$T_1 = a\, T_0 r^{\gamma - 1}$$
$$T_2 = a\, \varrho\, T_0 r^{\gamma - 1}$$
$$T_e = a\, \varrho^{\gamma}\, T_0$$

where r is compression ratio; a is explosion ratio $= \frac{p_1}{p_a}$; ϱ is cut-off ratio $= \frac{v_2}{v_1}$

$$\therefore \eta_i = \frac{r^{\gamma - 1}\{a - 1 + \gamma a (\varrho - 1)\} - (a\varrho^{\gamma} - 1)}{a r^{\gamma - 1} - a\varrho^{\gamma} + \gamma a (\varrho - 1) r^{\gamma - 1}} \quad . \quad (1)$$

This expression is unwieldy, but it reduces to a very simple and interesting form when ϱ is taken as unity, *i.e.*, the case of the gas engine or constant volume combustion cycle. Expression (1) then becomes

$$\eta_i = 1 - \frac{1}{a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

a result which shows that the efficiency has no dependence upon compression ratio. Not only so, but since the value of a for a given air/fuel ratio increases as r diminishes, it should therefore be better to work, in conjunction with regeneration on the lines suggested, at as low a compression ratio as is practically possible. This analysis is but another example indicating the desirability of reviewing general notions on the value or otherwise of high compression ratios. One thing it does indicate is that regeneration of any kind in high compression engines cannot give relatively such good results as would be obtained along the same lines in those of the low compression type. It will be observed also that expression (2) is what may be termed the "*regenerator air standard efficiency*," which takes the place of the air standard efficiency expression without regeneration, *i.e.*,

$$\eta_i = 1 - \frac{1}{r^{\gamma - 1}}$$

Another interesting point to note also is that (2) implies that rich mixtures will yield higher efficiencies in conjunction with regeneration, whereas in practice without regeneration weak mixtures are the more economical.

In conclusion, the writer would say that he considers the main value of this result to lie in its elucidation of the relations which must hold, approximately at least, in any scheme involving gas regenerators. To carry out the cycle suggested would require, so far as he can see, the external compression of the working fluid in a separate compressor, this working fluid being then discharged into a receiver or regenerator heated by exhaust gases, a scheme, it will be observed, which possesses few desirable features.

W. J. WALKER, Ph.D.

May 7th.

DESIGN FOR AN EXPRESS LOCOMOTIVE.

SIR,—Like Mr. Poultney, we think that the possibilities of the four-coupled locomotive are by no means exhausted. Further, we hold that the steam locomotive in general is still capable of development, but along lines which, whilst differing somewhat from those hitherto accepted, nevertheless need not involve novelties of more or less doubtful utility.

Although we are in agreement with the broad principles of Mr. Poultney's proposed three-cylinder 4-4-2 locomotive, yet there are, we consider, some points which might be profitably discussed. To begin with, we would favour a boiler having an enlarged outer fire-box, from which the steam would be taken, dispensing with a dome, unless this be provided for the purpose of conveniently housing a top-feed arrangement. The enlargement of the fire-box would permit of the use of a bigger fire-box tube plate, together with wider spacing of the tubes, the advantage of which need not be stressed. The smoke-box—like most smoke-boxes, for that matter—might be modified beneficially.

Dealing with the engine, we would recommend four cylinders, a divided drive, and Walschaerts' valve gear. The outside connecting-rods could be materially shortened by extending the piston-rods and putting the slide bar bracket close to the leading driving wheel. We would place the inside cylinders well forward, in order to obtain connecting-rods of reasonable length, and set the inside cranks at 135 deg. to the outside, thereby securing a torque greatly superior to that of the three-cylinder design in which the cranks are 120 deg. apart. Power being a more important factor than speed, the piston stroke should be 28in., instead of the 24in. suggested by Mr. Poultney. High piston speed is not necessarily a drawback; what does matter is the number of reciprocations per minute. The long-stroke engine appears to have as good a capacity for speed as any other, coupled with a climbing power not to be attained by the short-stroke

* "Proceedings," Inst. Mech. E., December, 1920.

† "Proceedings," Inst. C.E., Vol. CCX., 1919-20.

engine, but eminently desirable in a modern express locomotive intended for hauling heavy loads at high speed. The 30in. stroke Great Western engines have attained practically 88 miles an hour, from which fact the conclusion may fairly be drawn that a long piston stroke does not of itself interfere with fast running.

In our opinion, it is questionable whether three 18in. by 24in. cylinders would in reality furnish the power necessary for the pulling of a load of 600 tons at 60 miles per hour, with a cut-off of only 25 per cent., whatever the power according to theoretical calculations may be. More probably the work could be done only with a relatively high terminal pressure, resulting, in a sense, in a waste of fuel.

Increased cylinder area is important, but it is obvious that, in the case of the simple engine, the potentialities of that area are reduced in proportion as economy in steam and coal consumption is studied by shortening the cut-off. Logically, a four-cylinder double-expansion locomotive is the remedy; one, say, with 17in. high pressure and 25½in. low-pressure cylinders, with a piston stroke of 28in.; driving and coupled wheels 6ft. 6in.; and an adhesion weight of 45 tons, the latter figure being one that the excellent balancing of the reciprocating parts would render permissible. A compound locomotive having the foregoing cylinder dimensions would, for the same quantity of steam taken from the boiler as for Mr. Poultney's three-cylinder, 18in. by 24in., simple engine, be cutting off at 43 per cent., as against, say, 30 per cent. In other words, for a like steam and coal consumption, the four-cylinder double-expansion engine would be exerting a greater power than the said simple locomotive. There is no necessity to point out that compounding is being developed and extended on the Continent, and the old argument that it does not pay to employ it here is strangely at conflict with European experience. Why is it that the continental locomotive engineer appears to place almost unlimited faith in the double-expansion superheated engine, and to regard it as the key to the efficient and profitable operations of heavy express traffic? The matter is surely worthy of further consideration here.

Mr. Poultney's coal consumption figure, 2½ tons per hour (about 87 lb. per mile at 60 miles per hour), is manifestly very high, and must reach, if it does not overstep, a fireman's physical capacity.

The suggested adhesion weight of 45 tons, jointly on two axles, for an engine with inside cranks at 135 deg., would be of approximately equal value to 67½ tons for an ordinary two-cylinder engine. The proposed four-cylinder locomotive would be a prompt starter and first-rate accelerator.

The double-bogie tender designed by Mr. Poultney appears to be excessively heavy, involving unnecessary dead weight.

May 8th. F. W. AND A. J. BREWER.

GREAT WESTERN EXPRESSES.

SIR,—In your issue of March 2nd you published an interesting article on the above subject, in which it was stated—on page 221, first column—that "Reference to Table B shows that the impracticable timing of 22 min. for the 19¾ miles to Banbury was never adhered to."

The journals have been examined and the running times of five trains between Leamington and Banbury tabulated from February 26th to March 27th. This record shows that the timing is adhered to under normal conditions.

London, W. 2, April 30th. R. H. NICHOLLS.

[In reply to the accompanying letter I would point out that the official results were obtained with normal winter train loads, which are the lightest of the year, leaving Leamington with seven or eight coaches. As nearly the whole of my runs are made solely to test locomotive capacity, such trips are taken in holiday seasons, when the heavier train loads provide a more severe test and one more suitable to the design of the locomotive. In my article the figures in the tables showing coach loads bear this out. The word "impracticable" was intended to apply only to trains with heavy loads such as were recorded in the article. Never in the extensive experience of myself and two friends has Banbury been passed in 22 min. from Leamington with a load of 290 tons or over. With lighter loads such as obtained during the period mentioned in the official letter the booking is practicable, though usually at least a fraction of a minute is lost. Presumably guards' journals do not deal with fractions of a minute. For example, an express that left Leamington at 12.34½ p.m. and passed Banbury at 12.57½ p.m. would have its times appear in the journal as 12.35 p.m. and 12.57 p.m. respectively. On this basis some of the runs recorded in the article might conceivably have kept the 22 min. timing. There is no doubt that the Great Western Railway six-coupled express locomotives could pass Banbury in 21 min. from Leamington with suitable loads if the authorities thought it worth while. It is very evident that the Great Western Railway express running has improved even on the high pre-war standard since the accession to office of the present general manager. Not until January, 1923—by which time the corrected proofs of the article had been returned—did I have a run when the train passed Banbury in 22 min. or less from Leamington. In this case a load of eight coaches weighing 268 tons, forming the 12.5 p.m. ex Birmingham, passed milepost 86¼ in Banbury Station in 21 min. 28 sec. from the Leamington start. The 22 min. timing is hardly warranted by the requirements of the schedule, as can be gathered from the fact that in the article several heavy trains which passed Banbury in times from 24½ min. to 25 min. were running well to time approaching Paddington, without having resorted to high maximum speeds. Neither does this 22 min. timing tend to economical running, seeing that the next 5¼ miles of easy falling gradients to Aynho Junction are allowed as much as 5 min. On no unchecked run in the article were the full 5 min. taken; but on five occasions mentioned therein the times varied from 4 min. 2 sec. to 4 min. 19 sec., while even with the load of 406 tons the time was only 4 min. 36 sec.—THE WRITER OF THE ARTICLE.]

LOCOMOTIVE "BOOSTERS."

SIR,—We have been much interested in reading the article which appeared on page 419 of your journal, and note you refer to Van Helmholtz's "booster" of 1895. We think it will be of interest to your many locomotive engineering readers to see a drawing of a steam bogie we fitted in 1865 to one of the engines built by us for the Tudela and Bilbao Railway. We do not know for a definite fact whether or not this design constitutes the first "booster," but it certainly precedes the engines you refer to by many years.

The auxiliary engines had link motion and so were reversible, but there was no automatic cut-out to function at a predetermined speed, nor was there any clutch to render the whole idle; all the moving parts of the engines were always in motion whenever the locomotive was running, but a separate regulator steam cock was fitted, so that the auxiliary worked "dead" idle when not required for traction purposes.

We regret we have no records whatsoever regarding the performance of this experiment of nearly sixty years ago.

For BEYER, PEACOCK AND CO., Limited,
ROBERT WHITELEGG,
General Manager.

Manchester, May 4th.

AMERICAN BOILER RATING.

SIR,—I have read with interest Mr. Brownlie's article on the tests made at the Lakeside, Milwaukee, power-house. I agree with the writer's condemnation as unscientific of the American use of the so-called "boiler horse-power." Unfortunately, an error has been allowed to slip into his definition of this unit, as given at the foot of column 1, page 480. The American boiler horse-power is equivalent to a boiler output of 34.5 evaporation units—*i.e.*, 34.5 lb. water evaporated from and at 212 deg. Fah.—*per hour*, and not, as stated, per square foot of heating surface of the boiler. Thus a boiler having an output of 34,500 evaporation units per hour is a 1000 horse-power boiler, whatever be its heating surface. If this boiler has a heating surface of 10,000 square feet it will be operated at what American engineers call "100 per cent. rating"; if the heating surface were 5000 square feet it would be operated at 200 per cent. rating; but in either case it would be giving 1000 boiler horse-power.

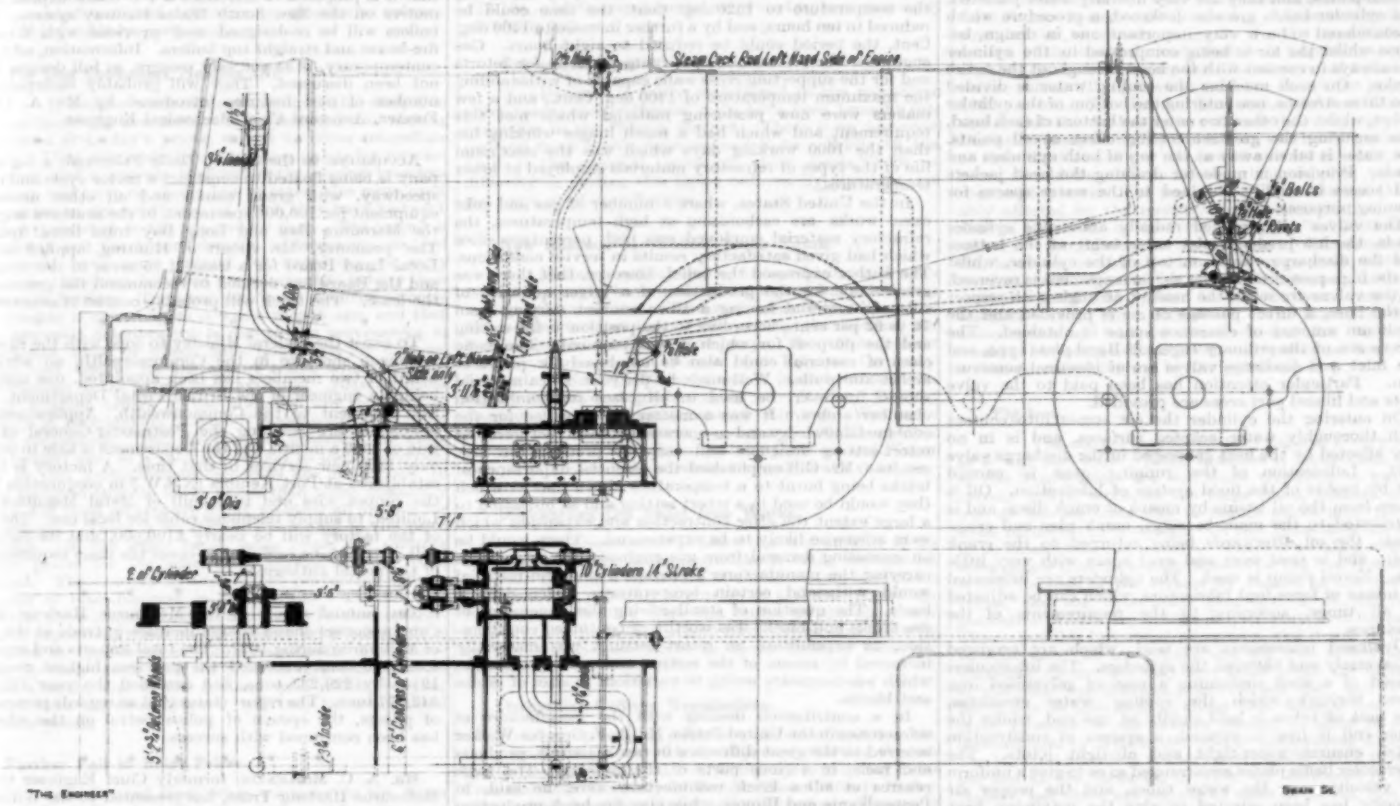
As much confusion exists sometimes as to the meaning of American boiler outputs and "ratings," it is probably worth while to call attention to this error. G. A. ROSSETTI.

Bolton, May 7th.

THE LATE MR. JOHN WILLIAMSON.

SIR,—With reference to your article on the late Mr. John Williamson on page 469 of THE ENGINEER of May 4th, I note you state that he was the author of a most interesting and historically valuable work on the subject of Clyde steamers which traced the developments of the vessels from the time of the Comet onwards. This is an error, as the book was written by the late Captain James Williamson, my father, who was a brother of the late Mr. John Williamson. GEO. T. WILLIAMSON.

Whaley Bridge, May 7th.



BEYER PEACOCK LOCOMOTIVE FITTED WITH A "BOOSTER," 1865

STEEL ARCH RAILWAY BRIDGE.

INCREASED weight of locomotives and increase in traffic have led the Michigan Central Railroad Company to build a new bridge across the Niagara River gorge, just below the Niagara Falls, to replace the famous old cantilever bridge, which was built in 1883 and strengthened in 1900. The new bridge, close alongside but not parallel with the old one, is to be a deck arch span of 640ft. between centres of end piers, and having a 100ft. plate girder span from each end to the solid rock of the cliffs. The rise of arch is 105ft., the depth of arch truss at crown is 20ft., and the rails will be about 240ft. above the river. Posts 40ft. apart and having an inward batter of 1 in 8 will rest on the lower or curved booms, and carry the upper horizontal booms, which are to be spaced 30ft. apart on centres. The shoe or end pins will be 19in. diameter, but all truss connections will be riveted with the exception of pin connections for some of the short posts near the crown, which will be subject to heavy bending stresses. The form of the lower boom is a parabolic curve. On each upper boom there will be a heavy longitudinal girder, supported on cast steel chairs at the panel points of the truss. Between them transverse floor beams, 13ft. 4in. apart, carrying the longitudinals which support the deck, are to be fixed. Four 15in. rolled joists will be under each line of rails, and will be covered with a steel deck and protective concrete slab on which the ballast will be laid. The bridge is designed for two eight-coupled engines, with 35-ton axle loads, and a total weight of 495 tons on a 104ft. wheel base, followed by a train load of 3½ tons per foot of each track.

THE directors of the Spanish copper companies, the Rio Tinto, Tharsis, Pena, and Huelva, also the Mason and Barry Company, in Portugal, have agreed to pool their production with a view to selling on a common basis, in order to avoid competition.

Electrically-driven Air Compressors

To the order of a Durham Colliery, the Ingersoll-Rand Company, of 165, Queen Victoria-street, E.C. 4, has recently supplied an interesting compressed air plant, consisting of four compressors, each having a capacity of 2500 cubic feet per minute, at a pressure of 75 lb. per square inch. The illustration on page 500 gives a general view of the plant, which is laid out on very good lines. The low-pressure cylinders are 28in. in diameter, the high-pressure cylinders 18in. in diameter, and the stroke is 18in. Each compressor is driven by a self-starting salient-pole three-phase motor wound for a pressure of 2750 volts, and a periodicity of 40 cycles per second. The rotor of each motor is mounted directly on the compressor shaft, between the main bearings, the general design and arrangement resulting in a unit which takes up a minimum amount of floor space, and there is ample room for inspection whilst the sets are in operation. All the parts are also accessible, so that they may easily be overhauled.

The air cylinders are supported throughout their length on sole-plates, and they are very liberally water-jacketed. The cylinder heads are also jacketed, a procedure which is considered to be a very important one in design, because whilst the air is being compressed in the cylinder it is always in contact with the head throughout the entire stroke. On each machine the cooling water is divided into three streams, one entering the bottom of the cylinder jacket, whilst the other two enter the bottom of each head, thus ensuring the greatest cooling effect at all points. The water is taken away at the top of both cylinders and heads. Provision is made for draining the head jackets and access is readily obtained to the water spaces for cleaning purposes.

The valves are arranged radially about the cylinder heads, the low-pressure inlet valve being at the bottom and the discharge valves on top of the cylinder, whilst on the high-pressure cylinder this arrangement is reversed. As the valves are set in the head at an angle with respect to the bore, a direct passage of air is provided and the minimum amount of clearance space is obtained. The valves are of the ordinary Ingersoll-Rand plate type, and the inlet and discharge valves are of identical construction. Particular attention has been paid to the valve seats and liberal port areas are provided.

On entering the cylinder the air comes into contact with thoroughly water-jacketed surfaces, and is in no way affected by the heat generated in the discharge valve port. Lubrication of the running gear is carried out by means of the flood system of lubrication. Oil is taken from the oil basins by means of crank discs, and is distributed to the main bearings, crank pins and cross-heads, the oil afterwards being returned to the crank basin, and is used over and over again with very little loss. No oil pump is used. The cylinders are lubricated by means of force-feed lubricators, which can be adjusted at all times, according to the requirements of the machines.

Overhead intercoolers are used, which are arranged transversely and between the cylinders. The intercoolers consist of a shell containing a nest of galvanised iron tubes through which the cooling water circulates. The nest of tubes is held rigidly at one end, whilst the other end is free to expand, a system of construction which ensures water-tight and air-tight joints. The intercooler baffle plates are arranged so as to give a uniform air velocity over the water tubes, and the proper air velocity has been selected to give the maximum heat transfer through the tubes with the minimum amount of cooling water and the minimum pressure drop across the intercooler. As the air is cooled, condensation naturally occurs, and arrangements are made for drawing off the condensate so as to keep the intercooler shell free from water at all times.

It has been found necessary in direct-connected electrically driven air compressor design to use constant speed motors, because of the complexity and comparative inefficiency of the schemes for obtaining sufficient speed variation by electrical means. Consequently, one of the most important features of the design has been the development of means for regulating the air output capacity with the compressor operating at constant speed, and the selection of the clearance controller for this purpose is the result of many tests on a large number of machines. The automatic clearance controller consists of a number of clearance pockets which are automatically put into communication with the ends of the cylinder in proper succession, the process being controlled by a predetermined variation in the receiver pressure. Regulation is obtained in a number of stages, viz., full load, three-quarter load, half load, quarter load, and no load.

When the compressor is operating at partial capacity a portion of the air is compressed into the clearance space instead of passing through the discharge valves on the return stroke, and this air expands and gives up its stored energy to the pistons. The intake valve remains closed until the cylinder pressure equals the intake pressure, and the inlet valves then open automatically and free air is admitted to the cylinder for the remainder of the return stroke. Thus the intake capacity is reduced without reducing the intake pressure. Reduction in power with this method of control is practically in direct proportion to the reduction of load, and the regulator is simple in construction and entirely automatic in action. The discharged air from each of the compressors, shown in the illustration, is carried through 10in. pipes with easy bends to an after cooler, and from this after cooler the air is then conveyed to two air receivers 20ft. long and 6ft. in diameter, each receiver having ample capacity to deal with the air from two compressors. The two receivers are coupled together by means of straight-way valves and bridge pieces, but it is possible to use them independently. From the receivers the air is carried in a 12in. main down the pit where it is used for working coal cutters for haulage purposes, and so forth. The circulating water for cooling purposes is supplied by an Ingersoll-Rand "Cameron" pump, which has a capacity of 550 gallons per minute, and is directly coupled to a 10 horse-power Metropolitan-Vickers motor, designed for a pressure of 440 volts and 40 periods per second.

Each motor has its own switch panel, whilst the meters, &c., are situated in a room adjoining the main building. The cables are run in conduits underground.

Refractory Materials.

A TWO days' Conference of the Refractory Materials Section of the Ceramic Society was held at Bournemouth on May 3rd and 4th.

In a paper on "The Use of Refractory Materials in Gas-works," Mr. G. M. Gill said that a large amount of retort and fire-brick material was available, which gave satisfaction to gas engineers as long as the temperature in the combustion chambers of retort settings did not exceed 1280 deg. Cent. It was necessary, however, to meet the increase in the demand for gas, to carbonise at higher temperatures, and thereby raise the rate of carbonisation. The importance of the time factor might be gauged, said the author, by the fact that whilst at a temperature of 1280 deg. Cent. a 10½ cwt. charge of coal could be carbonised in a 20ft. retort in twelve hours, by increasing the temperature to 1320 deg. Cent. the time could be reduced to ten hours, and by a further increase to 1400 deg. Cent. the period could be reduced to eight hours. Gas engineers were, therefore, specifying material for retorts and for the supporting cross walls capable of withstanding the maximum temperature of 1400 deg. Cent., and a few makers were now producing material which met this requirement and which had a much longer working life than the 1000 working days which was the maximum life of the types of refractory materials employed at lower temperatures.

In the United States, where a number of gas and coke oven works are carbonising at high temperatures, the refractory material employed was high percentage silica which had given satisfactory results in service conditions. The author expressed the belief, however, that there was great scope for the production of a larger quantity of siliceous material having a silica content varying from 76 to 92 per cent., according to the position in the setting and the purpose for which it was required. The same class of material could also be employed for producer arches and walls. Well made 95 per cent. silica material should, however, be used in all cases for combustion chamber arches. It was a matter which called for the conbined knowledge and co-operation of manufacturers and retort-setting designers and users to produce the best results. Mr. Gill emphasised the essential importance of bricks being burnt to a temperature above that at which they would be used in a retort setting and so obviating to a large extent the after contraction and expansion which were otherwise likely to be experienced. There would be an increasing demand from gas engineers for refractories carrying the manufacturer's guarantee that the material would withstand certain temperatures under definite loads. The question of standardising the dimensions of fire-bricks and blocks was worthy of continued consideration, as expenditure on retort settings was materially increased by reason of the sorting and cutting of bricks which was necessary owing to variations in sizes of bricks and blocks.

In a contribution dealing with the manufacture of refractories in the United States, Mr. A. F. Greaves-Walker referred to the great difference in raw materials, products and fuels, in various parts of the country. The large centres of silica brick manufacture were, he said, in Pennsylvania and Illinois, while clay fire-brick production was located in Pennsylvania, Missouri, Kentucky, Ohio, Maryland, and New Jersey. The chrome and magnesite plants had been mainly established on the Atlantic Coast. The high heat duty fire-bricks in American practice were made of mixtures of flint fire-clay and plastic bond clay, the flint clays having a fusion point of cone 32 to 36, and the plastic clays of cone 29 to 32. A great majority of all shapes and many 9in. bricks were made by hand, but the stiff mud or steam press process was also largely employed. The development of the soft mud machine had not been so rapid as might have been expected, notwithstanding the fact that it was a cheap process and gave a product of high quality. The new automatic brick machines were designed so that six men could make and handle from 4000 to 5000 bricks an hour. New developments in machines for the production of silica brick suggested that the day of the hand moulder on all but difficult shapes was numbered. Dry press processes were finding favour, and the latest types of presses could be operated at a speed which would produce from 1800 to 2000 bricks an hour. The hot floor drying process was being replaced wherever possible by other methods, principally the tunnel dryer heated by waste gas. A number of firms had installed humidity dryers which reduced both the drying period and the breakage. The round down-draught kiln was still the favourite type for burning. The greatest advance had been made in methods of producing magnesite and chrome bricks. Special mechanical presses had been put into service operating at a pressure of nearly 10,000 lb. per square inch and capable of making four bricks at a stroke as well as a number of special shapes up to 24in. long by 12in. wide.

Plant equipment had much improved during the past ten years with an associated reduction in the labour required per thousand bricks as well as better product. Both the stiff mud brick machines and the soft mud machines had been modified and improved in details. The entire refractories industry was organised on a task basis, and wages were governed to a considerable extent by the scale paid by steel companies. The men engaged in mining or in unloading cars, grinding, making, setting or wheeling, were given a certain tonnage or number of thousands to handle for a day's work, and when the task was finished they discontinued work for the day. Supervision was principally confined to inspection in order to keep the product up to standard.

The other papers on the agenda included one on dolomite, by Mr. L. M. Parsons; another describing an investigation carried out at Leeds University by Mr. H. S. Houldsworth and Mr. John Cobb on the behaviour of clays, bauxites, &c., when heated, and a short contribution on the abrasion of fire-clay materials, by Mr. Walter C. Hancock and Mr. W. King, which dealt with work carried out at the Imperial College of Science. It was shown that fine-grained fire-bricks resisted abrasion better than those of coarser grain, and that abrasion increased at higher temperatures.

Australian Engineering Notes.

THE Electricity Supply Committee of the Sydney City Council recommended a substantial reduction in the charges for electric current, to come into force as from April 1st. The reductions include one farthing per unit off the charges for current for lighting, three-tenths of a penny off the charges for current used for power for manufacturing purposes, and 20 per cent. reduction in the charge for the hire of electric motors. On July 1st next it is proposed to bring into effect a 10 per cent. cut in the charges for public street lighting throughout the metropolitan area.

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THE *Industrial Australian* reported in a recent issue that it is proposed to introduce a 4–6–0 new express locomotive on the New South Wales Railway system. The boilers will be re-designed and provided with Wootten fire-boxes and straight-top boilers. Information, adds our contemporary, is as yet very meagre, as full designs have not been discussed. They will probably incorporate a number of new features introduced by Mr. A. D. J. Forster, Assistant Chief Mechanical Engineer.

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ACCORDING to the *Sydney Daily Telegraph*, a big company is being floated to construct a motor cycle and cycle speedway, with grand stands and all other necessary equipment for 100,000 spectators, in the southern angle of the Maroubra Bay and Long Bay tram lines, Sydney. The promoter, Mr. Albert J. Hunting, applied to the Local Land Board for a lease of 75 acres in the vicinity, and the Board has decided to recommend the granting of the lease. The track will probably consist of concrete.

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To assist the Federal Ministry to cope with the existing telephone shortage in the Commonwealth, an advisory board of two members has been appointed, one member being an engineer of the British Postal Department, who has been lent to the Commonwealth. Applications for telephones are reaching the Postmaster-General at the rate of 2500 a month, but the Department is able to supply only 1800 new services in that time. A factory is being established at Port Kembla (N.S.W.) in conjunction with the copper wire and tube mill of Metal Manufactures, Limited, to supply telephone cable for local use. The cost of the factory will be nearly £100,000, and its capacity will, it is said, be sufficient to cover the main requirements of the postal authorities.

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THE annual report of the Melbourne Harbour Trust Commissioners shows a large increase in trade at the port of Melbourne during 1922. The total imports and exports, 4,521,856 tons, exceeded the previous highest record—1914—by 229,235 tons, and exceeded the year 1921 by 542,177 tons. The report states that as regards prevention of pillage, the system of police patrol on the wharves has been continued with success.

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MR. A. C. MCKENZIE, formerly Chief Engineer to the Melbourne Harbour Trust, has presented to the Williamstown Town Council a comprehensive report on a proposed new harbour scheme at Williamstown, which occupies a spit of land marking the southern extremity of Hobson's Bay, and is already the loading port for immense quantities of wheat and wool. Under the projected scheme twenty new berths are provided for, in addition to a breakwater, and adequate sheds and railway facilities. The aggregate cost would be £3,210,000.

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IN view of the importation of considerable quantities of wireless apparatus to meet the demands of amateurs and others, the Customs Department has issued a series of tariff decisions relating to these duties. It has been decided that both fixed and variable condensers, crystal and electrolytic detectors, rheostats, inductance coils—honeycomb and coupled coils—intervalve transformers, valve sockets, and complete tuning sets, shall be charged 27½ per cent. under the British preferential tariff, 35 per cent. under the intermediate tariff and 40 per cent. under the general tariff. Valves will be admitted free under the British preferential tariff, but duties of 5 per cent. under the intermediate tariff and 15 per cent. under the general tariff will be applied to them.

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PROSPECTS of cotton growing on a large scale in the Northern Territory have been considerably brightened by recent experimental planting. The seed was imported from America and planted in December, and the plants are stated to be uniform in growth, full in flower, and very healthy. The Australian Cotton Growing Association is making arrangements for the erection of two gins at Cobdogla, on the river Murray, and has commenced the erection of a ginnery at Newcastle (N.S.W.).

ENGINEERING GOLFING SOCIETY.—The Spring Meeting of the Engineering Golfing Society was held on the Coombe Hill course on Wednesday, the 9th inst., 54 competitors taking part in it. In the morning, Medal Round, in the 1st Division, the "President's Challenge Cup" and Memento were won by E. W. Timmis with a score of 87—8=79; the second prize going to H. C. Siddeley with a 90—10=80. In the 2nd Division there was a tie with 80 net, but as the result of a play off the "Wilson Challenge Cup" and Memento were won by H. G. Hale, whose original score was 91—11=80; the second prize falling to P. B. Brown, who had scored 95—15=80. The scratch prize (Captain's) was won by C. R. D. Pritchett with 84. In the afternoon, Foursomes—18 holes round against bogey—the first prizes were taken by E. C. MacKellar and Walter Phillips and the second prizes by A. H. Beatty and H. L. Williams. There had been a tie at all square between these couples, but the prizes were won, as stated, as the result of a play off.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

The Trade Position.

TRADE is undoubtedly quieter in Staffordshire generally. Several ironworks are now wanting orders, having only isolated mills at work. The nut and bolt industry in the Black Country has quietened down considerably, the strike of boilermakers having affected the work in operation at the shipyards. The chain trade also is less active. There is very little new business in iron and steel forthcoming and, as orders are gradually worked off, production—especially in South Staffordshire—is decreasing. The marked bar houses are rather more fortunate, sufficient new business having come forward to keep the firms moderately busy. Demand for steel materials is checked by the uncertainty of the outlook, and buyers are awaiting developments, which they contend will take the form of a definite break in prices. Purchases are restricted to actual requirements, speculative transactions being entirely postponed.

Pig Iron Consumers Holding Off.

It became more evident than ever this week that consumers of pig iron are not to be tempted into making purchases at to-day's prices, except to cover immediate needs. They resolutely refuse to place orders for forward delivery, and it appears that unless the market broadens smeltors will have no choice but to enter once more upon the process of price deflation, of which they have had such dreary experience in the not remote past. The output is increasing and the export demand is decreasing, so that consumers have some ground for expecting an early revision. Smelters, however, are reluctant to believe their control is passing. They say that in all essential respects the market is as strong as it was a month ago, and that any apparent deterioration is due to the nervousness of merchants, some of whom have quantities for disposal which they bought for the export trade, which has not materialised to the extent they expected. Blast-furnaces really wanting orders in the Midlands are reported on 'Change in Birmingham to-day—Thursday—to be making slight concessions. But the furnaces generally are quite well booked and, as a rule, are behind in their deliveries. One or two Northamptonshire firms are understood to have accepted slightly lower prices than those nominally ruling, but most makers are firmly resisting all appeals for concessions. There is no sign of weakening in the price of coke. On the other hand, some ovens are quoting higher prices for the renewal of contracts from June onward. The scarcity of fuel is still preventing the re-starting of blast-furnaces in this district. The decisive factor in the pig iron situation appears to be the hopelessness of expanding trade on the present price basis. It is regarded by consumers as entirely artificial. They have made up their minds that the position of producers is no longer tenable, and as the demand with which the year opened loses its momentum, it will only be re-animated by lower prices.

Further Fall in Billet Prices.

Semi-finished steel prices continue on the down grade. As orders become exhausted and foreign competition becomes more formidable, the steel works, which are now making large production, are conceding reductions. Soft billets are being put on the market by merchants at lower prices than the makers will entertain. They have been further weakened this week, sales being made at less than £9. Some mills quote £9 2s. 6d. to £9 5s., but on the Birmingham market to-day—Thursday—it is stated business can be done at £8 15s., and while this may be regarded as the bottom of the market, £9 is a fair level. Belgium is cultivating this business with some keenness, and is underquoting local steel makers, offers being made this week on the basis of £8 5s. or £7 17s. 6d. for bloom sizes. The Belgians state that they can now give delivery in three weeks or a month. The reduced price of billets has had an effect upon re-rolled material, small bars having sustained a reduction. They are quoted at £11 10s., but this is by no means the minimum. The wagon building industry continues to make heavy demands upon the steel trade of the district, and with fresh contracts coming along, this happy state of affairs should continue for some time. Users of finished steel are watching the market for signs of cheaper materials, but producers have not so far definitely changed their front. There is no longer an immediate shortage to exploit, because buyers are content to mark time, believing that when they have used up the material they have in stock or on order they will be able to effect replacements on easier terms. It is well known that a large amount of business is pending in the constructional department, but contracts are being held up in the expectation of lower prices. Generally the quotations from the large steel works are unaltered. These works are quite well situated for orders, and are fairly confident of their ability to maintain operations until the present reaction, which many of them believe is temporary, has passed. Structural steel values remain as last week, joists and angles being quoted £10 10s. Belgian competition is less effective for finished material. Offers of joists this week have been on the basis of £8 15s. Antwerp, equal to £10 delivered, a price so near that of local makers as to offer no attraction. Delivery is also very much slower from Belgium, customers occasionally having to wait as long as three months for finished material.

Steel Scrap Values.

The price of steel scrap has slumped badly. At the quarterly meeting it was impossible to buy under £5 per ton, but some sales have been effected this week at £4 5s., and the amount of material available is increasing with the large output of steel. A good deal of scrap is on offer from the Continent at competitive prices.

Belgian Bar Iron.

The Belgian bar mills do not appear to be making much headway in their endeavours to re-enter the Birmingham market, though the gap between the prices they quote and those which have ruled here is widening ominously. They are now offering nut and bolt bars at prices which work out at about £9 15s. delivered in the Black Country. This is at least £1 10s. below the competing material from the Staffordshire works, and consequently it is being bought to some extent by manufacturers of nuts and bolts. Home quotations are not appreciably affected so far, but the position is less strong than it was, and the persistent pressure from the Continent is bound ultimately to have its effect on the market. There is very little business passing in this material. Among nut and bolt makers competition is keen for slender orders. They will undoubtedly be glad to avail themselves of any relief that comes within reach. Makers of marked bars find an outlet for their production, which, if not large, is fairly well sustained and quotations are firm at £13 10s. A strong effort is being made by all bar iron makers to maintain prices, in view of the recent rise in ironworkers' wages, and the high price still demanded for forge pig iron. Unmarked bars are fairly maintained at £12 10s., and favoured works are stated to be occasionally obtaining £13.

Galvanised Sheets.

Business is fairly maintained in the galvanised sheet trade, and additional mills have been brought into operation in the Bilston district. There is an improved demand from South America and Cuba. While £9 10s. f.o.b. is the nominal quotation, there seems to be no difficulty in getting this figure reduced by about 5s. per ton for a good specification.

New Business for Rolling Stock Firms.

Midland rolling stock firms, which, as I have reported recently, have been having a good run of business, welcome this week some additional orders for goods wagons. The contracts have been given out by the London and North-Eastern Railway Company. The Metropolitan Railway Carriage and Wagon and Finance Company, Limited, of Saltley, Birmingham, it is understood, is to supply 800 covered goods wagons; the Midland Railway Carriage and Wagon Company, Limited, Washwood Heath, 750 12-ton mineral wagons and 500 12-ton open goods wagons; Birmingham Railway Carriage and Wagon Company, Limited, Smethwick, 30 goods brake vans.

Dismantling Old Sheet Iron Works.

It is regrettable to learn that yet another of the old Black Country sheet ironworks is being dismantled, and that there is a likelihood of the same fate overtaking a second, and probably a portion of a third. Years ago Bilston and Bradley were the centre of the sheet iron industry, but periods of slump have passed and one after another the old ironworks in these districts have disappeared.

Derbyshire Colliery Negotiations.

I am given this week to understand that negotiations are taking place with the object of effecting the sale by the Staveley Coal and Iron Company to the Clay Cross Coal and Iron Company of Bond's Main Colliery, Derbyshire, which has been closed since the miners' dispute of 1921. It was then stated that if the pit were closed it would be unprofitable to reopen it. The Clay Cross Company has several pits in the neighbourhood, so that it is thought it will be possible to effect economies in the management, and to make the pit pay its way.

Fewer Midland Workless

It is gratifying to be able to record a further substantial decrease in the number of workless in the Midlands. Of the nineteen towns for which unemployment figures are available all of them, with the exception of five, show a decrease in the number of those out of work during the week ended April 30th. Small increases are recorded at Dudley, Stourbridge, Brierley Hill, Walsall and West Bromwich. The net decrease for the whole area is 1923. It is satisfactory to note that in some of the large industrial areas the amount of unemployment shows a consistent decrease. Thus for Birmingham the numbers were 41,827, as against 42,511; for Coventry, 3468, as against 3939; for Smethwick 5991, as against 6208; and for Wolverhampton 8278, as against 8394. The total number of men unemployed was 120,500, as compared with 122,272 in the previous week.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

General Outlook.

ANOTHER week has gone by without bringing any fresh life to the iron and metal markets, and the belief is confirmed that we are in for a period of quietness, and in the case of the ferrous metals of declining prices. With regard to the non-ferrous metals the position is different, for with the exception of lead these are all on, or nearly on, a pre-war basis so far as prices are concerned. When the industrial and commercial world gets back to pre-war conditions in all matters, we shall be able to compare relative prices more accurately; but at present almost all the non-ferrous metals appear cheap when compared with fuel and iron. The slight revival of trade which occurred between between February and April seems to be passing away, and it is clear that the disorganisation of Europe prevents any revival from going very far. Some politicians are telling us all to seek within our own Empire consolation for the terrible state of Europe; and probably this is with a view to reviving the idea of a "Zollverein" for the British Empire. German words are, of course, out of fashion, so the "Zollverein" will now be called something else.

Metals.

The steady decline in the standard copper market was arrested at the end of last week, and there was a slight re-action, but whether or not this means the beginning of a revival in copper one cannot say. The circumstances remain unfavourable to the development of any large business. The world is poor, and probably some time must pass before surplus wealth can be created which would lead to any large expansion in engineering, cable communications and enterprises which would consume great tonnages of metals. Nevertheless, standard copper is on the low side at £70 per ton or thereabouts, and it seems fairly safe to hold full stocks. Refined ingot copper—best selected—at one time touched £73 per ton, showing a fall of £6 since the beginning of April, whereas the fall in electrolytic for the same period was only £4 per ton. Best selected ingot, therefore, looks rather cheap at present. Apparently the output of copper in America is still on the increase, while at the same time the demand from Europe seems to be decreasing. American domestic consumption, however, is good. In the manufactured section of the trade the only matter of importance to the engineer is an increase in the official price of brass condenser tubes. The price was raised to 1s. 3d. per pound—£140 per ton. The demand for scrap metal has fallen off again, and the dealers have reduced their buying prices. Dealers here say that they can buy as much old gun-metal as they want at £48 per ton, and if this be the case, engineers should be able to secure their supplies on very reasonable terms. The market for tin was rather favourably affected by the recently published statistics, which showed a decrease in the "visible supply" of 2500 tons—rather a larger figure than was expected. The demand for tin, however, in this district is not very good; although the Lancashire demand has very little influence on the tin market. Lead and spelter have both been very quiet markets without much fluctuation. The falling off of the consumption of lead on the Continent has tended to weaken the feeling in the market, and spelter has been quiet on the decreased buying by the galvanisers.

Pig Iron.

The market here for foundry pig iron is very much as it was last week. Little business is being done here, as the ironfounders are still quite unwilling to pay the current prices, while, on the other hand, makers of pig iron do not see their way to reduce prices until there is some reduction in the costs. Of this there does not seem to be much chance at present. There is a feeling amongst some people that the export demand for pig iron is about to revive because of the refusal by France of the German terms, and the consequent prolongation of the disorganisation of industry in the occupied portion of Germany. This is possible but not at all certain, and it will be better to wait until we see export and pig iron active again. Cleveland makers are very firm again under the influence of this idea, but Scottish prices remain easy, and Scotch No. 3 was on offer here at about 132s. 6d. per ton. The price, however, is not yet low enough to allow of much consumption in Manchester or the surrounding districts. The Midland makers of foundry iron usually quote 107s. 6d. per ton at the furnaces, or 115s. 6d. delivered in Manchester, but there are reports of sales at 2s. 6d. less; or, if not sales, of offers. Hematite is rather easier, and two more Cleveland furnaces are to be started on this class of iron. The price is, rather absurdly, 2s. 6d. less than that of No. 3 Cleveland common iron. East Coast hematite, however, delivered in Manchester, would still cost as much, or rather more, than Scotch No. 3.

Steel.

The market for finished steel is in rather an uncertain state. Of course, if export business is about to revive, it will be easy to keep prices up; but the home consumption is not good enough yet to sustain the market. There has been no further definite reduction in prices here, and probably makers will now wait a little before they attempt to get further business by the process of cutting the quotations to tempt the buyer. Steel plates were quoted from £10 10s. to £11 per ton, and joists and angles from £10 to £10 5s.

Scrap.

The market for scrap is again very dull and quiet. Steel scrap is easier here, and it is doubtful whether £4 10s. per ton could be had for it on trucks in Lancashire. There is a small demand for wrought scrap at from 97s. 6d. to 100s. per ton delivered. Cast scrap is very much neglected, and it is difficult to find buyers now at any price. Nominally broken machinery is at 92s. 6d. to 95s. per ton.

Railway Charges.

At a meeting of business men in Manchester last Friday, Mr. Charles N. Lawrence referred to transport costs. Speaking for the London Midland and Scottish Railway, of which he is the chairman, Mr. Lawrence said that the company was anxious to set up an organisation that would be quickly responsive to the requirements of trade. It was anxious to reduce the cost of transport by eliminating unnecessary expenditure. He said that while endeavouring to reduce the charges by running the undertaking in an efficient and economical manner, at the same time regard must be had for the interest of the investors in railway stock. A prosperous railway system was better able to offer a generous transport service, because it could afford to make experiments. With regard to the reserves in the hands of the railway companies Mr. Lawrence said that they had been built up in order to bring the railway system back to its pre-war standard. The enormous drain on the railways during the war depreciated the main line tracks and working plant to a greater extent than was

generally recognised. Everything possible was being done to restore those tracks and working plant to their pre-war standard, together with other improvements which experience since 1913 had shown to be desirable in the interests of efficient and economical transport.

Textile Machinery Trade.

In spite of the high dividend announced during the last few days by one firm engaged in the textile machinery industry, namely, Tweedales and Smalley, Castleton, near Rochdale, I am informed that the prospect all round in textile machinery is by no means as favourable as it was twelve months ago. The exports of textile machinery have have already begun to decline. The mills in India, China and Japan are not doing so well, and on this account an early recovery from the downward tendency of the exports curve is scarcely probable. It will, therefore, be satisfactory to makers of this class of machinery to learn that there is an opening for improved trade with Italy, as the Italian spinning firms, which have deterred buying new plant owing to high costs, are now commencing to recognise that the prices of textile machinery are as low as they are likely to be for some time to come.

Sir Henry Hollingdrake.

Sir Henry Hollingdrake's death, at the comparatively early age of fifty-three, is greatly regretted by his wide circle of friends in Manchester and Stockport. Sir Henry was the governing director of the old-established firm of Henry Hollingdrake and Sons, ironfounders and mill furnishers, Stockport, and the Hollingdrake Automobile Company, but for some time he has not taken a very active part in either of these businesses owing to indifferent health, which necessitated his living at Porlock. He died last week while on a visit to Buxton. Sir Henry received his knighthood for services ungrudgingly rendered during the war in connection with the furnishing of comforts for prisoners of war—a movement which ultimately spread all over the country.

BARROW-IN-FURNESS, Thursday.

Hematite.

The hematite iron trade is quieter, but makers are well booked for some considerable time. Many customers who were anxious to place orders are now secure and are not in the market for more iron at present. They have fixed deliveries for some months ahead. Makers are not likely to increase the number of furnaces in blast, and there is every reason to expect that trade will gradually become normal again. The volume of trade consequent upon the Ruhr occupation does not amount to a very great figure now, and there is every reason to anticipate that it will not increase in the future. The supply of coke is now adequate for present requirements, and there is no fear of stoppage. In consequence of there being a quieter market prices are showing a slight downward tendency. There have not been any heavy shipments of pig iron during the past week, South Wales and Glasgow taking what there was. The American trade is not so heavy as previously, but there is still some business being transacted. Special qualities of iron are in fair demand, much of the output going to the Midlands.

Iron Ore.

The iron ore trade remains the same with the greater amount being consumed in the district. Cumberland is getting the bigger share of orders, and the mines in that county are working at normal output. The foreign ore trade is only moderate and no large cargoes are arriving at West Coast ports at present.

Steel.

The steel trade is only fairly employed. At Workington the rail mills have started again, but there are no heavy orders, and they are not likely to be engaged for long unless fresh orders are secured. The tire department is also still at work. At Barrow the rail mills continue to be engaged, and hopes are expressed that they may continue to have a long run. The foundries are fairly well employed, but there is room for improvement in this department. The hoop and small bar mills are both engaged on orders and are likely to be so for some time.

Shipbuilding and Engineering.

The Isle of Man Steam Packet Company's boats, which have been laid up at Barrow for the winter, have undergone or are undergoing overhaul in readiness for the coming season. There have been no additions to the fleet this year. Amongst this line are some of the speediest cross-channel vessels running.

SHEFFIELD.

(From our own Correspondent.)

The Pressure at the Furnaces.

CONDITIONS in the Sheffield steel trade continue practically unchanged. The open-hearth steel furnaces are still pouring out great tonnages of billets, to be used in the building of railway stock and machinery of various kinds, and the activity in this department is on a greater scale than ever before. A tremendous quantity of business was booked towards the close of last year, and in the early months of this, and the furnaces are working at almost their full capacity in order to supply the wants of steel consumers. Whether the manufacturers are making much profit is another matter. Some of the early contracts, taken in order to get the works running, will do little more than pay their way, and, although the later orders were accepted at considerably enhanced prices, makers say that they will yield no more than a fair return. At any rate, they are not reducing their prices, even though buyers are holding off and placing as little new business as possible. Makers of billets, wire rods and certain sections of steel have still enough work on hand to keep them going a couple of months, quite apart from new bookings, and have a fair amount of confidence in the future. For wire, corrugated sheets, and tin-plates there is a particularly good demand on both home and export account.

More Railway Work.

The departments producing railway steel continue very busy. Railway companies at home and abroad, which had allowed their renewals of stock to fall greatly into arrear, have been ordering on a large scale, this being particularly the case with India. Good business is sure to come to Sheffield as a result of the large new orders just placed by the London and North-Eastern Railway Company. This undertaking is having a great number of locomotives, carriages and wagons built both at its own works and at those of independent firms. In this district we are particularly interested in the orders given to the Doncaster plant, which comprise fifteen 2–8–0 three-cylinder coal engines, ten 0–6–0 shunting tank engines, sixty-four suburban carriages, 1000 12-ton open-goods wagons, forty brake vans and two twin sleeping cars. The York works are to build a large number of passenger vehicles. Thousands of wagons have also been ordered, and among the firms to receive a share are Clayton Wagons, Limited, Lincoln, 750 12-ton mineral wagons, and Charles Roberts and Co., Limited, Horbury, near Wakefield, 500 12-ton open goods wagons.

Lighter Steel Branches.

The unsatisfactory feature of the Sheffield situation is that the improvement in trade is so very one-sided. Usually, progress in the heavy steel trades has been followed, after an interval of a month or two, by a similar improvement in crucible steel, high-speed steel, tools, and the various other light sections. But in the present case that is not so. The crucible steel branch was the first of the local industries to feel the slump, and it is still suffering to a very serious extent. Here and there one hears of a slight improvement, but such cases are rare, and the general condition of the trade continues very unsatisfactory. The tool trades are employed only in patches.

Cutlery and Plate.

With regard to the cutlery and plate branches, one can do little more than repeat what has been said during the past month, which is, that activity is on a restricted scale. The demand for stainless steel knives from the general public has shown a serious falling off of late, and the competition in this department is so keen that business is often taken at very low prices. Proprietors of hotels and cafés are calling for large supplies of both cutlery and plate, and contracts for these constitute the bulk of the work on offer at present. The question of price enters very largely into the placing of this business, and it is, therefore, often secured by small firms who are not burdened with heavy overhead charges. In the pen and pocket cutlery department, the improvement noted in the first quarter of the year has not been maintained. The new stain-resisting silver, "Silanca," the development of which was announced at the recent joint meeting of the Faraday and other societies in Sheffield, is attracting much attention among members of the trade and the purchasing public. A good many of the local manufacturers are giving it a trial and making it up into various articles.

Town Gas from Coke Ovens.

The value of coke-oven gas for town lighting is being recognised on an increasing scale in this district. The latest proposal for extending its use comes from Chesterfield, where the Gas Committee of the Corporation, which already takes a small quantity from the Grassmoor Colliery, is desirous of trebling or quadrupling the supply. I referred last week to the fact that the Gas Committee was proposing to renew its carbonising plant, which is about a quarter of a century old, and that the erection of six beds of retorts was being considered as a first instalment. The plant altogether contains twelve beds of retorts, and the object of the increased use of coke-oven gas is to postpone the heavy expenditure on a full renewal as long as possible. A Ministry of Health inquiry has been held with regard to the Corporation's desire to borrow £5600 for the cost of laying the necessary mains. The Deputy Town Clerk stated that coke-oven gas was available at as cheap a price as the Corporation could manufacture gas. The agreed price was based on a sliding scale, under which the charge for coke-oven gas would go down as the price of coal at the pit fell, and the Corporation considered that it had made an excellent bargain, provided it could make arrangements for getting the gas to the central works, 3½ miles distant, and distributing it to the consumers.

NORTH OF ENGLAND.

(From our own Correspondent.)

Quiet Trade Conditions.

INDUSTRIAL matters generally in the North of England continue to be characterised by a pronounced lassitude. The spurt of activity which was the dominant note in the markets a few weeks ago seems to have completely spent itself, and it is difficult to make any reliable forecast as to the outlook, for so much depends upon politico-economic issues which trade is powerless to influence. The effect of the strike of boilermakers in the shipyards is being increasingly felt. More and more men are being dispensed with, and it is reported that agents have arrived from the Continent with the object of securing ship-repairing orders. The strike is holding up shipbuilding specifications. This, in turn, interferes with the rolling programmes at the steel works, and, consequently, is curtailing the consumption of pig iron. During the past fortnight there has been a marked falling off in business in the iron and steel trades, and many people attribute the quietness now prevailing to high level of prices. On the other hand, it may be that the lull in business is a normal consequence of repletion, aggravated in a large measure by the situation in the Ruhr, and that there will be a renewal of activity as soon as buyers find that this interruption has not seriously reduced the inherent strength of the position.

Cleveland Iron Trade.

Extreme quietness continues to characterise the Cleveland pig iron trade, and new features are difficult to discover. Whilst the output of pig iron is well maintained, and most producers have a good deal of work yet to execute, an uncertain feeling as to the near future is holding customers back, and negotiations are on a very limited scale. Consumers apparently deem it a sound policy to wait before making further commitments. The falling off has been most marked in the export trade, owing to the decline in consumption on the Continent, but home consumers will also buy only for prompt needs, obviously hoping for further price cuts before the time comes for current contracts to be renewed. Makers, however, are emphatic in their declaration that working expenses altogether prohibit further concessions. Quotations stand:—No. 1, 130s.; No. 3 G.M.B., 125s.; No. 4 foundry, 120s.; and No. 4 forge, 117s. 6d. Another furnace is to be started next week on Cleveland iron, making twelve in all producing this class of iron, out of a total of forty-eight operating on the North-East Coast.

Hematite Pig Iron.

There is not a great deal of inquiry in the East Coast hematite trade, but the comparative cheapness of mixed numbers is expected to attract buyers who usually use other kinds of iron. Most of the makers are well placed in regard to orders and decline to offer any further price concessions. Mixed numbers are quoted at 122s. 6d., and No. 1 at 123s. 6d.

Iron-making Materials.

Foreign ore prices are more or less nominal, owing to the continued idleness of the market. Large quantities of ore are coming forward under running contracts, but little new business is being placed. Best Rubio is quoted 24s. 6d. per ton c.i.f. Tees. There has been a stiffening in the price of coke for export, and the scarcity of supplies to the blast-furnaces is as marked as ever it was. Deliveries to the ironworks are heavily in arrears. The minimum price for good medium furnace coke is 44s. per ton delivered at the works, and some consumers are paying more.

Manufactured Iron and Steel.

There is a distinctly quieter tone in the manufactured iron and steel trade. Continental billets are being offered again, rollers are not so urgently awaiting supplies, and the shipyard strike is holding up the mills usually engaged on ship plates, angles, &c. Still, there are orders coming out for railway and constructional material, and a few export inquiries lend some measure of activity to the market.

The Coal Trade.

There is not much change in the Northern coal trade position, except that matters seem tighter than ever, with all the loading turns more than fully taken up, leaving hardly anything available for this month, and not a great deal for next. Inquiries are constantly being received from foreign importers, but in very few cases can they be induced to book ahead at the prices quoted, preferring to buy from week to week or month to month, in the hope of being able to get supplies cheaper later on. The appearances, however, just now would seem to indicate a gradually strengthening outlook. There is said to be a slight easing tendency in the case of some of the brands of Northumberland best steams. But it does not amount to much, as most of the producers and second-hand men are firmly indicating the top figures for any near date of shipment in the case of both screened and smalls, with second screened steams firm and unchanged. The Durham section of the market is, on the whole, firmer and more assured. There is a good deal of interest displayed in regard to forward contracting, but not much actual and definite business is being transacted. A large volume of inquiry, however, is said to be in the preliminary stages, and is more likely than previously to be placed, by reason of the fact that there is a stronger feeling of security than there was. A number of speculators and consumers, however, are still inclined to hold off even yet. The coke market is still strong for all furnace and foundry qualities. Gas coke is quiet and easy.

Tees Iron and Steel Imports.

Statistics presented at a meeting of the Tees Conservancy Commission this week show a considerable reduction in the quantity of pig iron imported into the Tees from Holland, Belgium, France, Norway, Sweden, Germany, and coastwise. During the past six months only 4125 tons of pig iron were brought into the river, as compared with 30,160 tons for the same period a year ago, and 106 tons in the corresponding pre-war period of 1913–14. Crude sheet bars, billets, blooms, slabs, &c., imported during the six months ending April reached 37,365 tons, as against 27,822 tons for the same time a year ago, and 24,134 tons in the 1913–14 period. Bars, plates, angles, rails, sheets and joists totalled 6349 tons, as against 2869 tons a year ago and 13,460 tons in the 1913–14 period.

Graving Dock Scheme.

The work of modernising the Tees Conservancy

Commission graving dock, which was held up by the war, is now being put in hand. The scheme of electrification is to be continued, and obsolete machinery replaced. Pneumatic and electric welding plants are also to be installed.

SCOTLAND.

(From our own Correspondent.)

Diminishing Activities.

MARKET conditions during the past week indicate still quieter times ahead. Buying has been most spasmodic, and the attitude of consumers is not clearly defined. Some are buying only immediate requirements, some are not purchasing at all, while others still inquire for future deliveries. The last mentioned, however, may probably be only in the nature of a test of the market. Generally speaking, prices are all against the ideas of buyers, and only material that simply cannot be done without is being bought. This curtailment of activities is noticeable in export directions as well as at home. Increased offerings of cheaper continental material have affected home markets somewhat, but in this case the question of deliveries favours local producers. There seems little doubt that higher prices and labour troubles are almost entirely responsible for the arrestment of industrial progress. With the outlook so obscure, it is pleasing to note here and there a sign of life with possible expansion. One or two smaller shipbuilding contracts have been added to those announced last week in connection with the industry at Greenock, while at the Kilwinning works of Messrs. William Baird and Co., three out of six furnaces which have been closed down for two years have been restarted.

Steel and Iron—Lack of New Business.

Though there is still an appearance of activity at the steel and ironworks, there is also a growing anxiety with regard to the future. Inquiries are very slow in coming forward, and manufacturers have little confidence in quoting with prices on their present level. Present costs of raw materials and transport leave little room for a decrease in steel and iron; but makers are apparently willing to do their utmost to meet consumers in the matter of price wherever possible, even though current rates are unchanged. Steel plates are doing very little, and sectional material is not too satisfactory. Sheets are fairly busy in all gauges, but slacker times are imminent. Bar ironworks are similarly placed. Employment is comparatively good at present, but orders are slowing down. Re-rolled steel bars are in fair demand for immediate consumption, but buyers are not now disposed to anticipate requirements.

Coal Market Unchanged.

With the collieries well booked up for the present month there has been practically no change in the market position. The scarcity of fuel maintains prices, especially in the case of washed materials. The day to day turnover is small, and future placings have shrunk, buyers evidently looking for an early drop in prices. An improvement has taken place in shipping conditions on the East Coast, and a fairly regular turn is now established at the Firth of Forth ports. The shipments for the past week were well up to recent standards, and amounted to 364,390 tons, against 347,320 tons in the preceding week, and 212,402 tons in the same week last year. Foreign shipments were not nearly so prominent as in recent weeks, being less than 50 per cent. of the total. Home demands for fuel are far below the usual, especially in the industrial sorts. Best classes of household fuel are busy, but inferior sorts are inactive.

Wages of Scottish Miners.

Scottish miners' wages are now subject to an increase of 4¼d. per day, bringing the day's wage up to 9s. 3¼d. It is anticipated that the next ascertainment will warrant a further increase in wages.

Coal Under the Forth.

The Fife Coal Company has the leasehold of the Crown coal which runs for three miles out into the Forth, and stretching from Seafield to Dysart. Hopes are entertained that a rich seam of coal exists, and the Fife Company operating on behalf of the Government, is well pleased with the result of the operations to date. Should present indications be fully realised, pits will be opened in the district near Kirkcaldy.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THERE has not been much, if any, change in the steam coal trade during the past week. Prices have not given way appreciably, and now that the Whitsuntide holidays are coming within measurable distance, it is very questionable whether values will display any alteration for the remainder of this month, though if any change does occur there is just a chance that prices may improve, on account of the restricted output and the heavy loading pressure which is being experienced at all the South Wales ports. Supplies of coal are unequal to the present demands, and the loading facilities are also inadequate, so that the list of waiting steamers is heavy. The non-unionist fight in the coalfield still goes on in certain areas, and it is impossible to regard the future altogether with equanimity, because of the dissatisfaction that exists on the wages question. Monday last was demonstration day in many areas in the coalfield, and, of course, there was a good deal of loud talk on the part of the leaders; but the attendances at the mass meetings were not on the scale of former years, nor do they appear to have been so enthusiastic. Resolutions of a varied character were passed, urging the abolition of the present agreement, resistance to the demand for an extension of the present working hours and insistance on wages being revised so as to be on a living basis. Some leaders advocated that the men should meet the owners' demand for an eight hours' day with a counter-blast in the shape of a six hours' day. The recent statement of the chairman of the Mining Association of Great Britain that the solution of the wage question is to be found in a return to an eight hours' day has naturally been taken up by some of the miners' leaders, and, according to one of them, the Blackpool conference of the Miners' Federation of Great Britain on the 20th inst. will be compelled to decide to tender notices terminating the present agreement. There is, therefore, the possibility that serious trouble may be ahead, just at a time when the industry is doing comparatively well, and when the wages of the miners may be improved as the result of the recent increased selling price of coals.

Non-Unionist Affairs.

Round about 1000 miners in the Afan Valley, Port Talbot, stopped work on Monday last, the collieries affected being the Ynyscorrwg, Glyncorrwg and Blaengwynfi pits. Notices had expired on the previous Saturday. The miners demonstrated against the mechanical workers, who refused to join the miners' organisation. The miners in the Merthyr and Dowlais districts intend to wage war against the non-unionist, and unless the men outside the fold come into line, notices are to be tendered on Saturday next. In the case of the Pontypridd district, notices which were recently served have been suspended for a month, to enable the lodges to exert their influence to get the non-unionists to rejoin the Federation.

Steel Works Restart.

The Ebbw Vale Steel Works made a restart on Monday last after being idle for a period of about eight months. A fairly substantial restart has been made, though, of course, all of the works have not yet been got going. The Siemens furnaces are in operation, but it will be some time before all departments can become active.

Docks Third Shift.

Towards the end of last week it was officially announced that the conditions accepted by a delegate conference of the trimmers and tippers respecting an extension of the working hours at the South Wales docks were the terms of settlement agreed upon by the representatives of the employers and men on April 12th last, when the members of the Court of Inquiry acted as mediators, except that minor details with respect to the actual working of the third shift remained to be settled. Since then arrangements were made for representatives to meet in London on Tuesday last to formulate the details and report to the chairman of the Court of Inquiry, after which it was expected that an early announcement would be made as to the actual terms of the agreement, and probably also the date on which the extra working hours are to come into operation.

Current Business.

The general inquiry from the Continent during the past week has been rather quieter, but this is partly due to the fact that coals for shipment this month are increasingly difficult to get, as collieries will not accept fresh commitments, in view of the curtailed output due to the Whitsuntide holiday, and in the meantime they have considerable quantities of tonnage in dock which they have yet to load. On the other hand, buyers abroad are reluctant to purchase ahead, as they appear to hold the view that prices are likely to come down, but as against this there is the real prospect that Germany will be again in the market for supplies, in which event prices are more likely to rise than come down. Apart, however, from the general inquiry being quiet, there are other inquiries on the market for fairly large quantities of coal for prompt shipment to Spain and for delivery over the second half of the month for other directions. At the moment, best Admiralty large coals are about 38s. to 40s., with second qualities about 37s. 6d. Small coals are very steady and supplies are scarce, especially the superior grades, which command about 30s. Patent fuel shows no change, and is quoted at 40s. to 45s., and coke remains pretty firm at 77s. 6d. to 80s.

Latest News from the Provinces.

WALES AND ADJOINING COUNTIES.

Docks Working Hours.

No definite agreement was arrived at in London on Tuesday respecting the third shift question, and therefore the chairman of the Court of Inquiry has been requested to resume the Court's proceedings so as to continue the negotiations. For this purpose a meeting has been provisionally arranged for to-day—Friday—at the Ministry of Labour.

Whitsuntide Holidays.

It has been arranged that the official holidays in the coalfield at Whitsuntide shall be three days, viz., 21st, 22nd and 23rd inst.

THE wireless station at Harbin, Manchuria, originally established by the Russians, has been redeemed by General Chang Tso-lin at a cost of some £20,000. Up to the present only official and press messages are handled by the station, but arrangements are being made to receive private messages.

LAUNCHES AND TRIAL TRIPS.

CUBA, twin-screw steamer; built by Swan, Hunter and Wigham Richardson, Limited, to the order of the Compagnie Générale Transatlantique, of Paris; dimensions, 495ft. by 62ft. by 38ft. Engines, two sets of turbines of Metropolitan-Vickers type; constructed by the builders; trial trip, April 13th.

BRITISH YEOMAN, oil tank steamer; built by Palmer's Shipbuilding and Iron Company, Limited, to the order of the British Tanker Company, Limited; dimensions, 440ft. by 57ft. by 33ft. 11in.; 10,200 tons deadweight. Engines, single-screw double-reduction geared turbines, pressure 200 lb.; constructed by the builders; launch, April 17th.

GLENLINNIE, single-screw steamer; built by Swan, Hunter and Wigham Richardson, Limited, to the order of the Great Lakes Transportation Company, Limited; dimensions, 250ft. by 42ft. 6in. by 20ft. 6in. Engines, triple-expansion, pressure 180 lb.; constructed by the builders; launch, April 18th.

EDIBA, twin-screw motor vessel; built by Harland and Wolff, Limited, to the order of Elder, Dempster and Co., Limited; dimensions, 420ft. by 54ft. by 35ft. 3in.; 6500 gross tonnage. Engines, two six-cylinder four-cycle Diesel oil; constructed by the builders; trial trip, April 18th.

MALOJA, twin-screw passenger liner; built by Harland and Wolff, Limited, to the order of the Peninsular and Oriental Steam Navigation Company; dimensions, 625ft. by 73ft. by 44ft. Engines, twin screws driven by two sets of inverted direct-acting quadruple-expansion engines, pressure 215 lb.; constructed by the builders; launch, April 19th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

HOLDEN AND BROOKE, Limited, of West Gorton, Manchester, inform us that their agency for the Birmingham district is in the hands of Messrs. Green and Jackson, Grenville Buildings, 12, Cherry-street, Birmingham.

T. W. BROADBENT, Limited, of Huddersfield, informs us that it has removed its London office from 73A to 17, Queen Victoria-street, E.C. 4, to which address it requests that all correspondence relating to the firm's London and export trade should now be addressed.

F. AND A. PARKINSON, Limited, of Guiseley, Leeds, inform us that the name and address of their Birmingham agents are now Messrs. Green and Jackson, Grenville Buildings, 12, Cherry-street, Birmingham. Telephone number, Central 1688; telegraphic address, "Jehanjay, Birmingham."

CHEMICAL ENGINEERING GROUP (Society of Chemical Industry) has removed its offices from 24, Buckingham-street, Strand, London, W.C. 2, to Abbey House (Room 308), Victoria-street, Westminster, S.W. 1, to which address it is requested that all communications to the Group should in future be sent.

JOHN THOMPSON, Limited, of Wolverhampton and Dudley, informs us that it is about to open a branch London office on the south side of the river, in addition to that at Windsor House, Kingsway, W.C. 2. Further particulars of the new branch, which will be in charge of a fully qualified engineer, will be published as soon as the office is established.

CONTRACTS.

THE UNDERGROUND COMPANY has placed a contract with W. T. Henley's Telegraphic Works Company, Limited, for high-tension electric cables for the Edgware and Hampstead Railway.

THE YORKSHIRE COPPER WORKS, Limited, has just received an order for the condenser tubes required in connection with the two Holt liners at present being built at Palmer's Shipbuilding and Iron Company, Limited, Jarrow. The same firm is at present supplying brass boiler tubes and copper superheater tubes required by the Western Australian Government.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, of Pittsburg, Pa., announces that it has just entered into a contract with the Virginian Railway Company for the complete electrification of the line between Mullens and Roanoke, in the State of Virginia, comprising 134 route miles and 215 miles of track. This line will handle a very heavy coal traffic with 6000-ton trains up a gradient of 2 in 100 and 9000-ton trains over the rest of the line. The contract includes the supply of 600-ton split-phase, 25-cycle, 11,000-volt locomotives, which are claimed to be the most powerful type ever contemplated.

THE INSTITUTE OF TRANSPORT.—The fourth dinner of the Institute of Transport was held at the Savoy Hotel on the evening of Thursday, the 3rd instant. The president, Sir Sam Fay, was in the chair and, in responding to the toast of "The Institute of Transport and the Transport Industry," proposed by Colonel Wilfred Ashley, Parliamentary Secretary to the Ministry of Transport, announced that the Prince of Wales had accepted the honorary presidency of the Institute. The toast "Our Guests" was proposed by Mr. E. S. Shrapnell-Smith and replied to by Sir E. H. Walton, High Commissioner for the Union of South Africa, and Mr. William Whitelaw, chairman of the London and North-Eastern Railway. The latter contrasted the chances of young fellows to-day with those prevailing when the companies were smaller and when there was a possibility of their merits being known. Promotion would now have to be determined by examination, and examination meant the crammer. The crammer always defeated the examiner. It was for that Institute so to develop its examinations that a candidate could show what he knew.

CATALOGUES FOR NEW ZEALAND.—The office of his Majesty's Trade Commissioner in New Zealand has written to the Department of Overseas Trade, stating that, with a view to revising the particulars on file in that office regarding goods manufactured by United Kingdom firms, it would be glad to be furnished with copies of the latest catalogues of interested manufacturers or with any other up-to-date data concerning United Kingdom productions. In particular, catalogues are desired in respect of the following classes of manufactures:—Wire stitching machinery; brush making machinery; fur cutting machinery; poultrymen's milling plant; petrol locomotives suitable for saw mills; biscuit making machinery; plum and prune stoning machinery; crystal glass; and safes. While the above goods are specially mentioned, catalogues or other descriptive literature will be welcomed in general from any United Kingdom manufacturers interested in trade with New Zealand. Any literature received will be filed for official reference and will also be available, on request, to inquirers desirous of purchasing British goods. Catalogues should be forwarded direct to his Majesty's Trade Commissioner in New Zealand, 11, Grey-street, Wellington, New Zealand, and the Department of Overseas Trade would, at the same time, be glad to be informed of any action which may be taken in the matter.

Current Prices for Metals and Fuels.

IRON ORE.

N.W Coast—	
Native	26/-
(1) Spanish	24/-
(1) N. African	24/-
N.E. Coast—	
Native	—
Foreign (c.i.f.)	24/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	6 7 6	—
No. 1 Foundry	6 2 6	—
No. 3 Foundry	5 17 6	—
N.E. Coast—		
Hematite Mixed Nos.	6 2 6	6 2 6
No. 1	6 3 6	6 3 6
Cleveland—		
No. 1	6 10 0	6 10 0
Siliceous Iron	6 10 0	6 10 0
No. 3 G.M.B.	6 5 0	6 5 0
No. 4 Foundry	6 2 6	6 2 6
No. 4 Forge	5 17 6	5 17 6
Mottled	—	—
White	—	—
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	13 0 0	—
North Staffs. Forge *	—	—
,, ,, Foundry	5 12 6 to 5 15 0	
(3) Northampton—		
Foundry No. 3	5 8 0 to 5 10 0	
,, Forge	4 18 0 to 5 0 0	
(3) Derbyshire—		
No. 3 Foundry	5 5 0 to 5 7 6	—
Forge	5 0 0	—
(3) Lincolnshire—		
Basic (none offering)	6 0 0 to 6 10 0	
Foundry	5 10 0	—
Forge	5 5 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.		
Hematite Mixed Nos.	6 17 6	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	12 10 0	—
Best ,,	—	—
N.E. Coast—		
Crown Bars	12 0 0	—
Tees	10 0 0	—
Lancs.—		
Crown Bars	12 15 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. Yorks.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	15 10 0	—
Midlands—		
Crown Bars	12 10 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	11 10 0	—
Gas Tube Strip	13 5 0 to 13 10 0	

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	13 0 0	—
Ship Plates ½in. and up	10 5 0	—
Sections	10 0 0	—
Steel Sheets, ¼in. to ½in.	12 10 0	—
Sheets (Gal. Cor. 24 B.G.)	—	20 0 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	10 10 0	—
Angles	10 0 0	—
Boiler Plates	14 0 0	—
Joists	10 0	—
Heavy Rails	10 10 0	—
Fish-plates	14 10 0	—
Channels	9 5 0	—
Hard Billets	10 15 0	—
Soft Billets	10 10 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	10 0 0	—
Light ,,	12 10 0	—
Billets	11 0 0	—
Manchester—		
Bars (Round)	12 0 0	—
,, (others)	10 15 0 to 11 0 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	10 10 0 to 10 15 0	
,, (Lancs. Boiler)	13 10 0	—
Sheffield—		
Siemens Acid Billets	13 0 0	—
Bessemer Billets	13 10 0	—
Hard Basic	10 15 0	—
Intermediate Basic	10 10 0	—
Soft Basic	9 10 0 to 10 0 0	
Hoops	12 15 0 to 13 5 0	
Soft Wire Rods	13 0 0 to 13 10 0	
Midlands—		
Small Rolled Bars	11 7 6 to 11 10 0	
Billets and Sheet-bars	8 15 0 to 9 5 0	
Gas Tube Strip	12 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets (f.o.b. L'pool)	19 10 0	—
Angles	10 10 0	—
Joists	10 10 0	—
Tees	11 10 0	—
Bridge and Tank Plates	10 15 0 to 11 0 0	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	23/3 to 24/9
Block Tin (cash)	206 10 6
,, (three months)	206 10 0
Copper (cash)	69 12 6
,, (three months)	70 5 0
Spanish Lead (cash)	24 12 6
,, (three months)	24 10 0
Spelter (cash)	31 16 3
,, (three months)	32 6 3
Manchester—	
Copper, Best Selected Ingots	75 0 0
,, Electrolytic	80 0 0
,, Strong Sheets	106 0 0
,, Loco Tubes	0 1 2½
Brass Loco Tubes	0 1 0½
,, Condenser	0 1 3
Lead, English	26 0 0
,, Foreign	24 15 0

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit
Tungsten Metal Powder	1/11 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23	10/6
,, 6 p.c. to 8 p.c. ,,	£21 0 0	8/-
,, 8 p.c. to 10 p.c. ,,	£20 0 0	8/-
,, Specially Refined		
,, Max. 2 p.c. carbon	£52 0 0	20/-
,, ,, 1 p.c. ,,	£62 0 0	22/6
,, ,, 0·75 p.c. carbon	£72 0 0	25/-
,, carbon free	1/6 per lb.	
Metallic Chromium	4/6 per lb.	
Ferro Manganese (per ton)	£16 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale unit	5/- per
,, ,, 75 p.c.	£21 0 0 scale unit	6/- per
,, Vanadium	17/- per lb.	
,, Molybdenum	9/6 per lb.	
,, Titanium (carbon free)	1/1 per lb.	
Nickel (per ton)	£130	
Cobalt	12/- per lb.	
Aluminium (per ton)	£82 to £100	

(British Official.)

FUELS.

SCOTLAND.

		Export.
Lanarkshire—		
(f.o.b. Glasgow)—Steam		26/-
,, ,, Ell		28/-
,, ,, Splint		30/- to 32/6
,, ,, Trebles		30/-
,, ,, Doubles		29/-
,, ,, Singles		29/-
Ayrshire—		
(f.o.b. Ports)—Steam		26/-
,, ,, Splint		30/-
,, ,, Trebles		30/-
Fifeshire—		
(f.o.b. Methil or Burntisland)—Steam		28/- to 30/-
Screened Navigation		33/-
Trebles		30/-
Doubles		29,9
Singles		29/6
Lothians—		
(f.o.b. Leith)—Best Steam		29/6
Secondary Steam		27/6
Trebles		30/-
Doubles		29,9
Singles		29/6

ENGLAND.

		Export.
(8) N.W. Coast—		
Steams		31/6
Household		46/8 to 57/6
Coke		48/-
Northumberland—		
Best Steams		34/6 to 35/-
Second Steams		32/6 to 33/6
Steam Smalls		23/- to 25/-
Unscreened		20/6
Household		25/- to 28/-
Durham—		
Best Gas		33/- to 35/-
Second		32/6
Household		25/- to 28/-
Foundry Coke		70/- to 72/6
Sheffield—	Inland.	
Best Hand-picked Branch	32/6 to 34/6	—
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	25/6 to 27/6	—
,, ,, House	23/- to 24/6	—
,, ,, Large Nuts	20/6 to 22/6	—
,, ,, Small ,,	18/- to 21/-	—
Yorkshire Hards	22/- to 24/-	—
Derbyshire ,,	21/- to 24/-	—
Rough Slacks	12/- to 14/-	—
Nutty ,,	10/6 to 12/6	—
Smalls	7/- to 9/-	—
Blast Furnace Coke (Inland)		24/- to 27/-
,, ,, ,, (Export)	f.o.b.	44/- to 47/-

(9) SOUTH WALES.

		Export.
Cardiff—		
Steam Coals:		
Best Smokeless Large		39/- to 41/-
Second ,, ,,		37/6 to 39/-
Best Dry Large		37/6 to 39/-
Ordinary Dry Large		35/- to 37/6
Best Black Vein Large		37/- to 38/-
Western Valley ,,		36/- to 37/-
Best Eastern Valley Large		35/- to 36/-
Ordinary ,, ,,		33/- to 35/-
Best Steam Smalls		29/- to 30/-
Ordinary ,,		25/- to 28/-
Washed Nuts		30/- to 35/-
No. 3 Rhondda Large		37/- to 39/-
,, ,, Smalls		30/- to 32/6
No. 2 ,, Large		32/6 to 34/-
,, ,, Through		29/- to 31/-
,, ,, Smalls		25/- to 27/-
Coke (export)		70/- to 80/-
Patent Fuel		40/- to 42/6
Pitwood (ex ship)		27/- to 27/6
Swansea—		
Anthracite Coals:		
Best Big Vein Large		45/- to 47/6
Seconds		42/6 to 45/-
Red Vein		32/6 to 35/-
Machine-made Cobbles		55/- to 60/-
Nuts		50/- to 52/6
Beans		45/- to 47/6
Peas		25/- to 26/-
Breaker Duff		12/- to 13/-
Rubbly Culm		17/- to 17/6
Steam Coals:		
Large		27/6 to 30/-
Seconds		25/- to 27/-
Smalls		19/- to 21/-
Cargo Through		22/- to 24/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

* Quotations extremely high and nominal.

French Engineering Notes.

(From our Correspondent in Paris.)

The "Civils" Anniversary.

THE 75th anniversary of the Société des Ingénieurs Civils de France has been celebrated with more than customary solemnity in the presence of the President of the Republic and members of the Government and of delegates from the engineering associations of seventeen foreign countries. The Société des Ingénieurs Civils had a very modest beginning, when a number of engineers from the Ecole Centrale formed a society, which was subsequently opened to engineers generally, and its progress was so rapid that it soon became the largest and most distinguished association of its kind in the country, with a membership that at present numbers 4500. Not the least of the merits of the Société des Ingénieurs Civils is the successful effort it has made to promote an international brotherhood of engineering by means of frequent gatherings and by a close association with foreign engineering bodies. The president this year is M. Guillet, director of the Ecole Centrale, who welcomed the foreign delegates, and then Sir Vincent Raven, vice-president of the Institution of Mechanical Engineers, presented the Institution's medal to M. Rateau for his work on aviation engines. Medals were also presented by M. Guillet, on behalf of the Société des Ingénieurs Civils, to thirty-two members who had belonged to the Society for fifty years or more. A reply was made for the recipients by M. Eiffel, who is the oldest and one of the most honoured members. Although the celebration was mainly a social function, some interesting contributions were nevertheless made by M. Jordan on the devastation of the industrial districts in the north and the work of reconstruction; by M. Janet and M. Bizet on the distribution of electrical energy; by M. Soreau on aeronautics; and by M. Percheron upon the piloting of aeroplanes by wireless. After a visit to the aviation grounds at Le Bourget there was an official reception at the Conservatoire des Arts et Métiers, and a private reception by M. and Madame Guillet at the Ecole Centrale. The completely successful character of this social gathering will certainly mark the date of the Society's anniversary.

Degree of Doctor of Engineering.

As a means of encouraging research work in the practical application of science a new degree of doctor of engineering has been created in the Faculty of Science at the universities. Candidates for the degree are limited to students who have obtained the highest distinction at a certain number of technical schools, of which a list will be prepared, and they must be presented by the directors of the schools; or to engineers possessing a university degree who have followed the courses of applied science in a university or faculty. The candidate must have been two years in the laboratory of a Faculty of Science, and at the examination must develop an original thesis before a jury composed of three members of the faculty. The degree of doctor of engineering does not confer upon the holder any of the prerogatives of doctor of science; but candidates who have obtained the highest marks as doctor of engineering can be recommended by the jury for examination as doctor of science under the usual conditions for obtaining that degree.

A Big Contract.

In the negotiations that have been carried out for a long while past for the construction of a free port at Budapest, it was expected that British and Belgian offers of participation would receive favourable consideration, in addition to the plan presented by Messrs. Schneider and Co., who desired to carry out the entire undertaking. It appears now that the Schneider proposal has been accepted and the contract signed, whereby a company is to be formed with a capital of a hundred million crowns, in which the Hungarian State will be represented for 60 per cent. and the French group for 40 per cent. The cost of constructing the port will be borne entirely by the Hungarian Government. Messrs. Schneider and Co. are backed by a French financial house, representing provincial banks, which has undertaken to raise in this country fifteen million francs. The contract provides for the construction of an extensive port on the Danube, which is the principal route for traffic in Central Europe, and the area and equipment of the port have been calculated for a trade development which is expected to be considerable in the early future.

Coke Supplies.

The consignments of coke from the Ruhr have been growing so rapidly that there would appear to be some justification for putting a number of furnaces in blast. Seeing, however, that hardly more than a third of the quantity necessary for normal consumption is forthcoming the situation at the best is not satisfactory, and some uneasiness has been occasioned by the Minister of Public Works recommending blast-furnace proprietors to stock one-third of the coke they are receiving to provide for emergency. This is taken as meaning that the Government is by no means sure of being able to continue supplies as soon as the stocks are exhausted in about two months' time. It is certain that unless the Germans consent to work at the ovens it will be quite impossible to maintain the present rate of supply, and there is indeed a prospect of the consignments practically ceasing altogether. French blast-furnace proprietors are, therefore, very loth to resume operations until something more definite is known as to the future. It is true that the French coke production is steadily increasing, and that if only a proportion of the Ruhr ovens can be kept working, it may be possible to provide sufficient to supply a third of the needs; but for the moment it does not appear as if the French have discovered a means of compelling the Germans to produce coke or of importing men to carry on the work in the presence of a hostile population. There is, however, a feeling in this country that the Government will succeed in getting coke from the ovens when the stocks are exhausted, although there may be some delay in doing so, and it is on account of this delay that the Minister of Public Works has requested blast-furnace proprietors to reserve a part of the present supplies to enable them to tide over a period of deficit.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics

When an abridgment is not illustrated the Specification is without drawings.

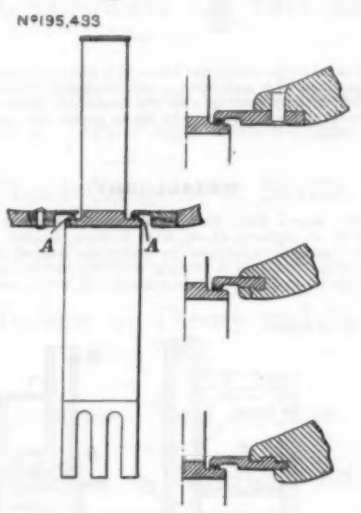
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TURBINE MACHINERY.

195,433. December 3rd, 1921.—STEAM TURBINE BLADING, K. Baumann, Northwood House, Barnfield, Urmston, Lancs.; and the Metropolitan-Vickers Electrical Company, Limited, 4, Central-buildings, Westminster.

This invention relates to turbines in which the blading is divided radially into two or more tiers, in each of which tiers the steam flows separately. In order to make steam-tight joints



at the divisions between the tiers, knife-edged packing strips A are arranged in conjunction with cylindrical shoulders on the blading. Alternative methods of fixing the packing strips are shown.—*April 3rd*, 1923.

DYNAMOS AND MOTORS.

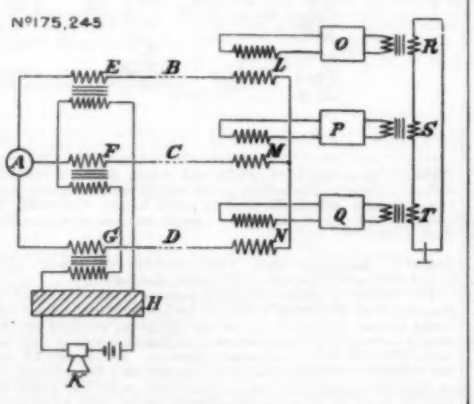
178,071. January 10th, 1922.—IMPROVEMENTS IN THE MANUFACTURE OF BRUSHES OF AGGLOMERATED GRAPHITE FOR ELECTRICAL MACHINES, "Le Carbone," Société Anonyme, of 12 and 33, Rue de Lorraine, Levallois-Perret, Seine, France.

The improvement in the manufacture of carbon brushes described in this specification consists essentially in adding to the mixture of graphite and gelatine in solution prior to the stoving of this mixture a certain quantity of a material which will render the gelatine insoluble, the substance employed for this purpose being preferably trioxymethylene or formaldehyde. This insolubilising substance forms with the gelatine a horny material, which is capable of being subjected to a very high degree of compression and does not possess the hygroscopicity of pure gelatine. The proportions of the different constituents may vary according to the results to be obtained. By way of example the following agglomerated graphite composition is given:—Graphite, 30 parts; solution of gelatine (gelatine 0.2 part to 10 parts of water), 30 parts; trioxymethylene, 0.6 part. The trioxymethylene is added to the mixture of graphite and gelatine in solution before the mixture is stoved. Under the subsequent action of the heat the trioxymethylene forms with the gelatine a horny substance possessing, it is stated, very special qualities. —*April 10th*, 1923.

TELEGRAPHS AND TELEPHONES.

175,245. November 24th, 1921.—IMPROVEMENTS IN HIGH-FREQUENCY TELEPHONY, Gesellschaft für Drahtlose Telegraphie, m.b.H., of 9, Tempelhofer Ufer, Berlin, S.W., Germany.

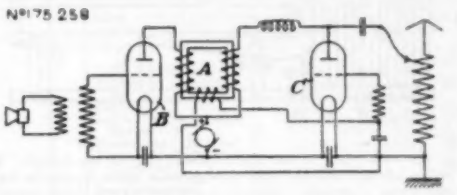
This invention relates to a high-frequency telephone system in which several interlinked or separate high-frequency currents with a constant phase difference are simultaneously acted upon



by the microphone and separately transmitted, while at the receiving end the incoming currents influence different receiving circuits acting upon a common telephone. In the diagram A is a three-phase generator delivering 3 × 10,000 periods. B C D are the three conductors including three transformers E F G, which, through an amplifier H, are influenced by the microphone K. L M N are three primary windings of three high-frequency transformers arranged at the receiving end, the windings being coupled to three valves O P Q. The output transformers R S T of the valves act upon the telephone. The lines B C D may be replaced by antennæ (*i.e.*, three transmitting and three receiving antennæ).—*March 26th*, 1923.

175,256. February 11th, 1921.—IMPROVEMENTS IN HIGH-FREQUENCY TELEPHONY, Gesellschaft für Drahtlose Telegraphie, m.b.H., of 9, Tempelhofer Ufer, Berlin, Germany.

This invention relates to high-frequency telephone transmitters of the type in which thermionic valves with control electrodes are employed for varying the amplitude of high-frequency oscillations in rhythm with speech and especially to arrangements in which the strength of the oscillations is so varied that the anode direct voltage is increased or diminished by speech. The currents due to the microphone are applied directly to the anode of a generating valve and also to the grid in such a way that when the oscillations are hindered by the lessening of the anode potential they are simultaneously assisted to a like degree by increasing the direct potential of the grid. This is preferably affected by generating a grid speech potential at an exactly opposite phase to the anode speech current by means of a transformer A provided with three windings, the first of which

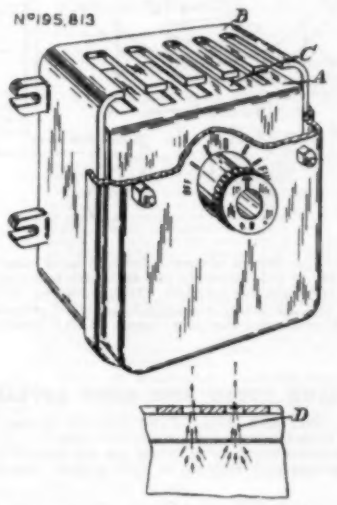


receives the potentials from the valve B. The second winding is in the anode circuit of valve C, and the third is the grid circuit of valve C. The back coupling necessary for generating oscillations is a function of $1/(E_g + a E_A)$, where a is a known valve constant, E_g is the grid direct potential, and E_A the anode direct potential. When E_A becomes smaller the back coupling necessary becomes larger or, which is the same thing, the back coupling required for the higher potentials is not sufficient for lower potentials and therefore the oscillations cease. The decrease of the anode potential so increases the grid potential that the back coupling necessary remains constant and therefore is correct for all potentials. This is attained by keeping the variable expression $(E_g + a E_A)$ constant. In order that $(E_g + a E_A)$ may be constant it is necessary that the grid speech potential should have the reversed phase of the anode speech potential and an amplitude lessened in the ratio of a to unity. The invention prevents the disappearance of the high-frequency oscillations when the anode potential is very low.—*April 12th*, 1923.

SWITCHGEAR.

195,813. February 2nd, 1922.—A HEAT DEFLECTING DEVICE, PARTICULARLY FOR ELECTRICAL RHEOSTATS AND THE LIKE, Thermal Electric Works (Hackbridge), Limited, of Hackbridge, Surrey.

The chief object of this invention is to provide means for dissipating the heat in rheostats. The invention consists in directing and shaping the uprising hot stream or streams of air so that the air escapes without materially impinging on the



casing. A deflector baffle plate A is provided at a short distance below the top wall B of the casing. The hot air escaping through the slots C is made to take the form of uprising air streams D. In this way, it is claimed, the casing remains comparatively cool.—*April 12th*, 1923.

BATTERIES AND ACCUMULATORS.

195,477. January 21st, 1922.—IMPROVEMENTS IN ELECTRIC ACCUMULATORS, Henry Leitner, of Regent House, Kingsway, London.

In the preparation of pastes of oxides of lead for electric accumulators exceedingly hard and durable compounds can be made, which, nevertheless, have not hitherto found commercial application on account of the extreme difficulty of converting them by simple electrolytic formation into peroxide of lead, whereas frequently such pastes are easily reduced to spongy or porous lead. The object of this invention is to retain the characteristics of hardness, durability and other mechanical advantages of these pastes. An example is a paste composed of lead monoxide and sufficient glycerine, diluted with water. To assist its conversion into peroxide of lead finely powdered manganese dioxide may be used in suitable proportions. On subsequent electrolytic formation of the paste, when set and hardened, the manganese dioxide, not only acts as an oxidising agent and carrier, but, by reason of its conductivity, assists the electrolytic action. Moreover, as it is ultimately decomposed and dissolved out of the paste, it renders the latter more porous. Instead of glycerine, treacle, molasses, tar and similar liquids may be combined with the lead oxide, and the paste may have incorporated with it a larger percentage of peroxide of lead, which is preferably manufactured electrolytically. The percentage of peroxide may be 20 per cent. by weight, and for special purposes even considerably more up to the point where this can be used without sacrificing the effective and satisfactory behaviour of the active material

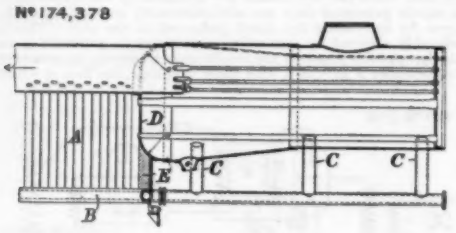
ultimately obtained. Whilst the use of peroxide of lead is indicated as a large ingredient of active material intended for anodes of electric accumulators, an admixture of powdered and preferably electrolytic spongy dried lead confers advantages in respect of making the paste conductive and is more specially suitable for cathodes.—*April 5th*, 1923.

LOCOMOTIVES.

174,378. January 24th, 1922.—LOCOMOTIVE BOILERS, K. Rezsny, 3, Varfokutcza, Budapest, 1, Hungary.

This boiler has a water-tube fire-box and a fire-tube barrel. The water-tubes A rise from lower headers B which are continued forward and communicate with the barrel by means of branches C C. The inventor lays great stress on the form given

N° 174,378



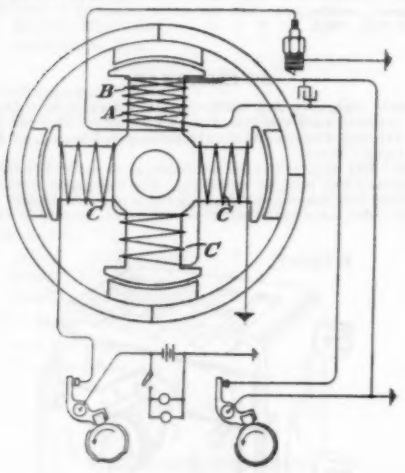
to the tube plate D and the adjacent part of the barrel. The radius of the flanging of the tube plate is made unusually large, and a sort of pocket is formed in the lower part of the barrel to accommodate sediment. This pocket is protected from the direct heat of the fire-box by the wall E.—*April 5th*, 1923.

MOTOR CARS AND ROAD TRAFFIC.

195,739. January 4th, 1922.—IMPROVEMENTS IN MAGNETO-ELECTRIC MACHINES, The British Thomson-Houston Company, 83, Cannon-street, and Arthur Primrose Young, of "Dovedale," Kenilworth.

According to this present invention a multipolar magneto-electric machine has windings on one or more of the poles, and the current generated in these windings is utilised for ignition purposes, while one or more of the remaining poles carry wind-

N°195 739



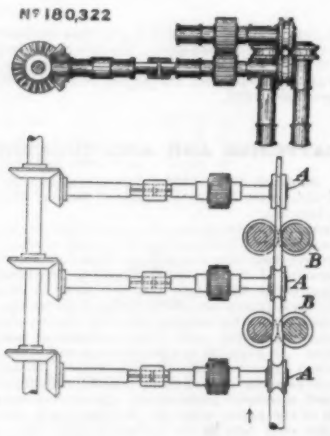
ings for the generation of current for lighting or other purposes, the number of pole pieces on the armature being equal to the number of permanent magnets. In the diagram A and B are primary and secondary windings for ignition purposes, whilst the windings C supply lighting current which is rectified.—*April 4th*, 1923.

MACHINE TOOLS AND SHOP APPLIANCES.

180,322. May 16th, 1922.—TUBE ROLLING MILLS, A. Papen, 4, Frankenstrasse, Düsseldorf, Germany.

The inventor proposes to reduce the diameter of tubes by a rolling process with rolls set at right angles. One set of rolls

N° 180,322

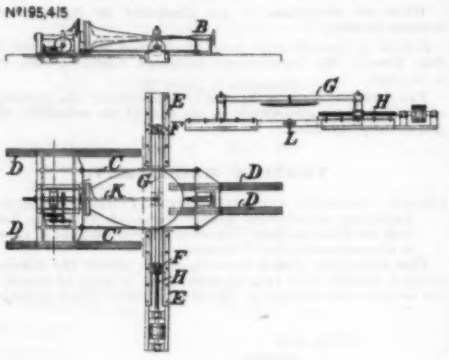


A A A is driven at successively increasing speeds by the gearing shown, while the other pairs of rolls B B are driven by frictional contact with the tube. The grooves in the several pairs of rolls are appropriately reduced in size.—*April 5th*, 1923.

195,415. October 22nd, 1921.—MACHINING PROPELLER BLADES, C. E. Clift and P. R. Parsons, St. David's Wharf, Millwall, London, E. 14.

The propeller blade is mounted on the spindle of a headstock A and is supported at the other end by a tailstock B. The two heads are tied together by the rods C C and slide on the ways D D. At right angles to these slides there are others, marked E E, which carry the heads F F of the cutter bar G. The cutter bar is reciprocated across the propeller blade by the screw H. A bar

N°195,415



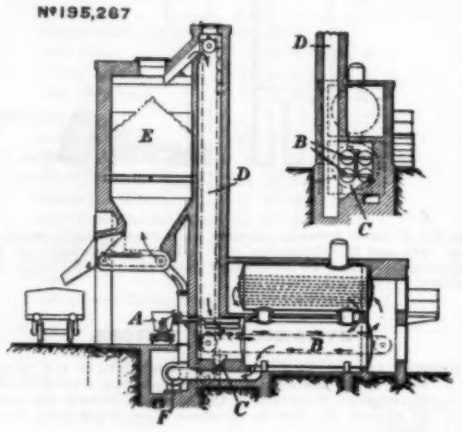
K is pivoted to the cutter bar frame at L directly below the tool. It is provided with rack teeth at the other end, and these teeth are connected by gearing with the headstock spindle. Means are provided for traversing the blade under the tool.—*March 22nd*, 1923.

METALLURGY.

195,267. March 23rd, 1922.—UTILISING THE HEAT OF SLAG, *B. E. D. Kilburn*, 31–33, *High Holborn, London, W.C.* 1.

This apparatus is intended to utilise the heat of molten slag or pig iron. The slag is brought from the furnace in trucks A and tipped into the trays of a conveyor B, which pass through

N°195,267



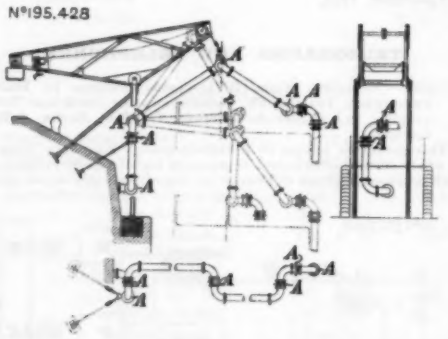
the flues of a boiler. The solidified contents of the trays are tipped out at C and taken by an elevator D to a storage hopper E. Neutral gases are circulated by the blower F up through the hopper, down the elevator shaft and through the boiler, in order to complete the cooling of the slag.—*March 29th*, 1923.

MISCELLANEOUS.

195,428. November 29th, 1921.—FLEXIBLE PIPES, W. H. Dorman and Co., Limited, 43, Foregate-street, Stafford, and O. H. G. Steed, 88, Tixall-road, Stafford.

This flexible pipe is intended to take the place of the armoured hose generally used in loading or unloading oil tank vessels. It comprises several lengths of ordinary steel pipe connected

N°195,428



together by right-angle bends and rotary joints arranged in different planes. The rotary joints are all marked A and permit the outboard end of the pipe to move in any direction. The weight of the pipe is carried by a small crane as shown.—*March 29th*, 1923.

195,497. February 14th, 1922.—SOFTENING WOOD, *J. Y. Johnson*, 47, *Lincoln's Inn-fields, London*.

This invention relates to improvements in treating wood with the object of rendering it soft to form a substitute for Florida cedar wood. According to the specification, wood of any kind can be softened by incorporating therewith aqueous soap solutions with the aid of increased pressure. Practically all soaps are suitable for the purpose of the invention; for example, lard or other fat, soaps, resin soaps, wax soap, as well as soapy compounds, such as sulphonates of fatty acids. The kind of soap best adapted for any special case and also other conditions depending on the nature of the wood to be treated may be ascertained by test experiments. Additions may also be made of waxes, fats, and the like, in a dissolved or emulsified condition. The solution may be employed either cold or warm, the pressure being preferably rather high; for example, say, 100 lb., 500 lb. or 1500 lb. to the square inch, or even more.—*April 5th*, 1923.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INSTITUTION OF AERONAUTICAL ENGINEERS.—The Engineers' Club, Coventry-street, W. 1. Lecture, "Low-power Flying," by Major M. E. A. Wright. 6.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION.—Royal Society of Arts, John-street, Adelphi, W.C. 2. Paper, "Some Notes on 'Ciment Fondu'—a Cement of High Initial Resistance—with Results of Chemical Analyses by Harley F. Knight, F.I.C.," by Mr. H. J. Davey. 7.30 p.m.

IRON AND STEEL INSTITUTE.—Institution of Civil Engineers, Great George-street, S.W. 1. Annual meeting. For programme, see page 401. 10 a.m. each day.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Durham Bursar's Lecture, "The Theory of Resistance to the Flow of Gases and Fluids in Pipes," by Mr. W. F. C. Cooper. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse, "Gaseous Combustion at High Pressures," by Dr. W. A. Bone. 9 p.m.

SATURDAY, MAY 12TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—South Wales District meeting. Joint visit with members and students of the Institution of Civil Engineers to the Merthyr Reservoirs. Paper by Mr. F. Harvey, acting engineer of the Taf Fechan Water Supply Board, entitled "The Waterworks Undertaking of the Taf Fechan Supply Board," will be considered and discussed. Train leaves Merthyr Station for Pontsticill 12.10 p.m.

TUESDAY, MAY 15TH.

INSTITUTE OF TRANSPORT.—Institution of Electrical Engineers, Savoy-place, W.C. 2. Graduates' and students' lecture, "The Design and Maintenance of Commercial Motor Vehicles," by Mr. G. J. Shave. 5.30 p.m.

WEDNESDAY, MAY 16TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Chamber of Commerce, New-street, Birmingham. Birmingham graduates' meeting. Paper, "Heat Treatment," by Mr. W. E. Benbow. 7.30 p.m.

ROYAL METEOROLOGICAL SOCIETY.—49, Cromwell-road, South Kensington, S.W. 7. General meeting. 5 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. "Industrial Lighting and the Prevention of Accidents," by Mr. Leon Gaster. 8 p.m.

SOCIETY OF GLASS TECHNOLOGY.—University College, Gower-street, W.C. 1. General meeting, 12 noon and 2.45 p.m. Annual dinner, Hotel Cecil, Strand, W.C. 2. 7 p.m.

THURSDAY, MAY 17TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—28, Victoria-street, S.W. 1. London graduates' meeting. Paper, "Heat Treatment," by Mr. W. E. Benbow. 8 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. "Engineering Problems Solved by Photo-elastic Methods" (Lecture I.), by Professor E. G. Coker. 3 p.m.

SOCIETY OF GLASS TECHNOLOGY.—Visit to the new works of James Powell and Sons (Whitefriars), Limited, Wealdstone, Harrow.

FRIDAY, MAY 18TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse, "Recent Studies in Alternating Magnetism," by Mr. W. M. Mordey. 9 p.m.

SATURDAY, MAY 19TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Eastern District meeting at Peterborough. 10.30 a.m.

TUESDAY, MAY 22ND.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Chamber of Commerce, New-street, Birmingham. Paper, "Ball Bearings," by Mr. A. Macaulay. 6.45 p.m.

SATURDAY, MAY 26TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Eastern District meeting at Southend-on-Sea. 10.45 a.m.

MONDAY, MAY 28TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The College, Loughborough. Loughborough graduates' meeting. Paper, "The Design of Connecting-rods for High-speed Engines," by Mr. M. Platt. 7 p.m.

TUESDAY TO FRIDAY, JUNE 5TH TO 8TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—Summer meeting at Manchester. For programme see page 322.

ROYAL INSTITUTION.—The annual meeting of the members of the Royal Institution was held on Tuesday afternoon (the 1st of May), Sir James Crichton-Browne, Treasurer and Vice-president, in the chair. The annual report of the Committee of Visitors for the year 1922, testifying to the continued prosperity and efficient management of the Institution, was read and adopted. The report of the Davy Faraday Research Laboratory Committee was read. Sixty new members were elected in 1922, and 63 lectures and 19 evening discourses were delivered. The books and pamphlets presented amounted to about 162 volumes, making with 426 volumes (including periodicals bound) purchased by the Managers, a total of 588 volumes added to the Library in the year. Thanks were voted to the President, Treasurer and Secretary, to the Committees of Managers and Visitors, and to the Professors, for their valuable services to the Institution during the past year. The following gentlemen were unanimously elected as officers for the ensuing year:—President: The Duke of Northumberland; Treasurer: Sir James Crichton-Browne; Secretary: Sir Arthur Keith; Managers: Sidney G. Brown, John Mitchell Bruce, Sir Dugald Clerk, John Ambrose Fleming, Sir Richard Glazebrook, Earl Iveagh, Sir Alexander C. Mackenzie, Robert Mond, Sir Edward Pollock, Alfred W. Porter, Lord Rothschild, Sir David Salomons, William Stone, Sir Alfred Yarrow, The Right Hon. Lord Justice Younger. Visitors: Sir Harry Baldwin, William A. Bone, Alfred Carpmael, Ernest Clarke, Edward Dent, Thomas W. Dewar, George H. Griffin, W. E. Lawson Johnston, Colonel F. K. McClean, Sir Malcolm Morris, W. Rushton Parker, Walter Peacock, Major C. E. S. Phillips, Hugh Munro Ross, Sidney Skinner.